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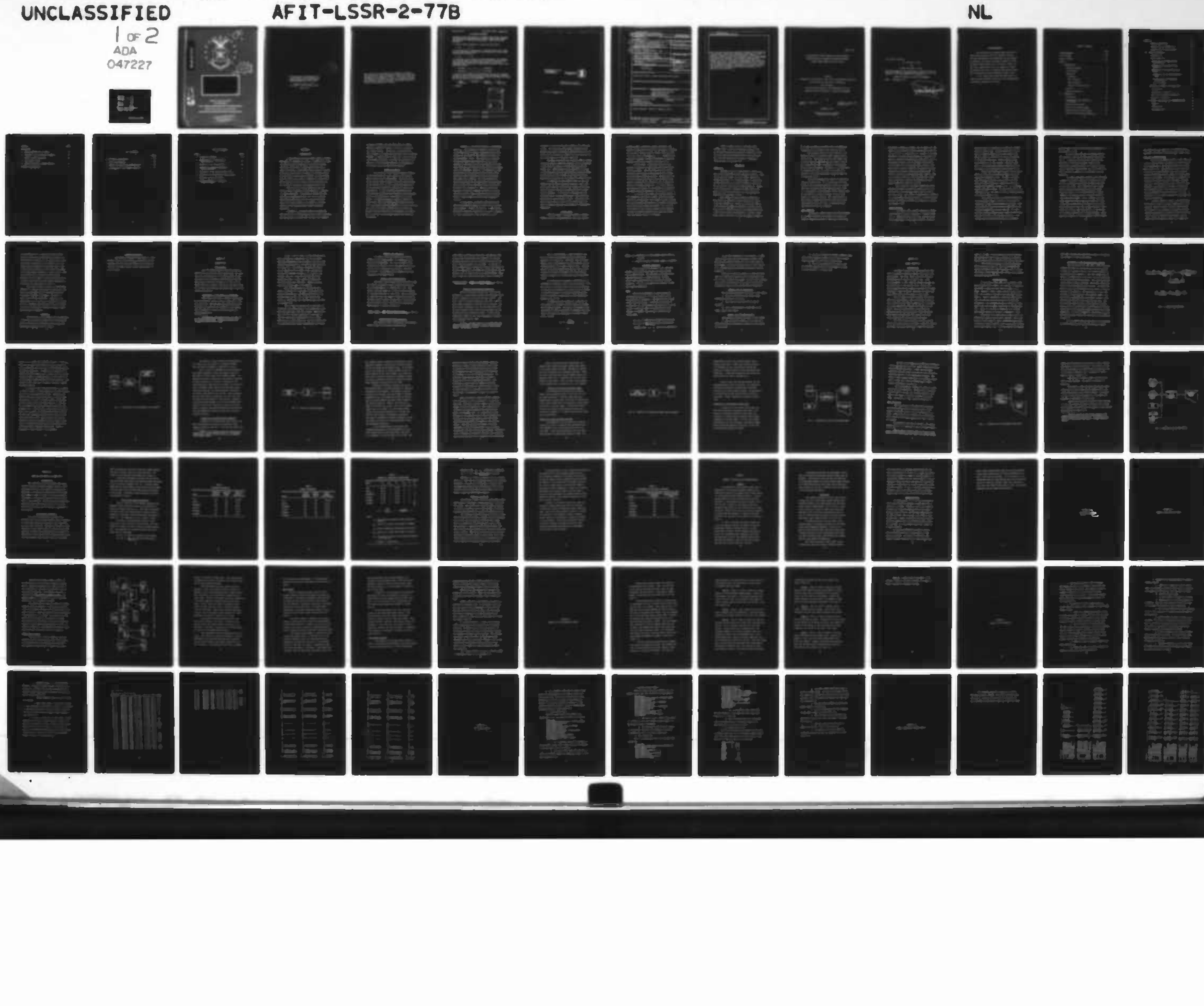

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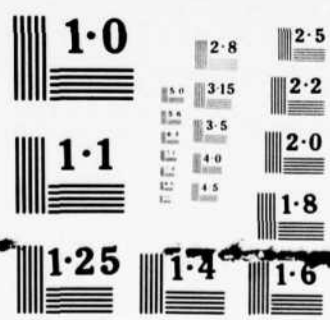

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Wright-Patterson Air Force Base, Ohio

AN EVALUATION OF THE CAPABILITY OF THE LOGISTICS COMPOSITE MODEL TO PROJECT THE MONTHLY AIRCRAFT SORTIE EFFECTIVENESS OF AN F-15 WING

Charles G. Davis, GS-12
Clifford T. Smith, Captain, USAF

LSSR 2-77B

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There has been considerable research on computerized generation of alternative flying and maintenance schedules in an effort to improve utilization of Air Force resources. However, no technique exists to evaluate the potential sortie effectiveness of alternative schedules. The Logistics Composite Model (LCOM) appeared to have the potential to perform the evaluation through simulation. The authors investigated LCOMs capability to accurately predict the sortie effectiveness of F-15 monthly flying schedules by simulating six actual F-15 monthly flying and maintenance schedules. Analysis of the results indicated that LCOM could not effectively evaluate alternative F-15 monthly flying schedules.

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AN EVALUATION OF THE CAPABILITY OF THE LOGISTICS COMPOSITE MODEL TO PROJECT THE MONTHLY AIRCRAFT SORTIE EFFECTIVENESS OF AN F-15 WING

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

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GS-12

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and

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has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT

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CHAPTER I

INTRODUCTION

A United States Air Force (USAF) Tactical Fighter Wing (TFW) is composed of a myriad of organizations ranging from munitions storage units to tactical fighter squadrons. While each of these organizations has a specific mission to perform and certain goals to achieve, their ability to perform as a team will directly affect how well the wing achieves its mission. As the ultimate goal of a TFW is to be able to respond to a combat situation, the wing's final success will be determined by its ability to accomplish its assigned combat role.

The combat role of most TFWs is to provide various types of tactical aircraft missions in support of stated objectives. The degree of success the wing achieves in accomplishing this role will be largely determined by the quality of its assigned aircrews, which is directly related to the amount of training received by the aircrews during normal peacetime operations.

Presently, a significant amount of peacetime aircrew training is accomplished during airborne missions, and the ability to provide safe, reliable, and properly configured aircraft when and where they are needed becomes an important element if a wing is to fulfill its mission (5:4-5). The ability to provide sufficient numbers of aircraft when and where they are needed depends, to a great extent, on how well a unit allocates its available resources. In a TFW, the allocation of a majority of the available resources is established by the monthly flying and maintenance schedule.

Problem Statement

A wing monthly flying and maintenance schedule is the end product of a great amount of interaction between operations and maintenance. Initially, operations submits their estimated flying hour requirements to maintenance, who, in turn, evaluate the capability of the maintenance complex to support the operational requirements. In many instances, disagreements may arise between operations and maintenance concerning what portion of the operational requirements will be supported. If these disagreements cannot be settled at lower levels, the wing commander must decide what portion of the operational requirements will be met (26:2-11). The result is a monthly schedule which contains compromises between operations and maintenance, and which may, or may not, be an optimum schedule for the wing to execute.

Currently, this entire process is accomplished manually. The maintenance schedulers involved have little opportunity to examine scheduling alternatives because of the amount of time required to generate a single schedule (3:vi). The coordination required between maintenance and operations, and the final approval of both agencies after any changes have been made, does not allow enough time for alternative schedules to be prepared. Adding to the complexity of the process are the many dynamic factors present within operations and maintenance that must be considered when preparing a schedule. Aircraft availability, aircrew qualification, and maintenance personnel skill level are but a few of the many factors that have to be taken into consideration. Because maintenance schedulers often lack necessary information concerning these factors, their scheduling decisions become based on value judgments and individual experience (3:iii).

In many cases, individual experience may be the most appropriate measure on which to base a scheduling decision. However, the opinion of experienced maintenance personnel, supported by continuing research is that *computerization could significantly aid* *schedulers in better allocating available wing resources* (3:xii). Two particular areas within scheduling that appear to be readily adaptable to computerization are the *generation of alternative schedules* and the *evaluation of the effectiveness of alternative schedules.*

The RAND Corporation has conducted several studies involving computer generated schedules, and has developed a model known as Decision Oriented Scheduling System (DOSS) (19). DOSS-produced flying schedules are based on available resources and established maintenance scheduling policies, with a change in scheduling policies generating a different set of alternative schedules (5:3).

In contrast to the intensive study of ways the computer can be used to generate schedules, there has been little research concerning how computer simulation might be used to evaluate the effectiveness of a particular schedule. If alternative schedules could be evaluated prior to being implemented, a more efficient allocation of resources might result. The problem currently facing the Air Force is that a means does not exist to measure potential effectiveness of alternative schedules.

Justification

With the advent of extremely expensive weapon systems, greatly increased manpower costs and tighter defense budgets, efficient resource allocation has become a major concern of both the Department of Defense and the USAF. General David C. Jones, Chief of Staff of the Air Force, has urged that, ". . . procedures be constantly reviewed for improved methods of achieving maximum results with available resources [25]."

Within a TFW, a significant amount of the available resources are dedicated to flying and maintaining aircraft. The efficiency with which these resources are utilized is determined by the success of the monthly scheduling process. The importance of the relationship between the scheduling process and resource allocation was pointed out by Mr. Morton B. Berman of the RAND Corporation: "*If we can improve* the scheduling process, we can improve the allocation of scarce resources throughout the Air Force [3:1]."

Air Force leaders feel that the improvement of the scheduling process will result in more efficient allocation of resources. As a result, several studies have been sponsored to determine if computer simulation could improve the scheduling process (3; 4; 15; 16). The results of these studies indicate that computerization of certain scheduling activities can significantly improve resource allocation.

Based on these results, it was felt that further study in the use of computer simulation as an evaluation device was warranted. Personnel of the Air Force Logistics Management Center concurred with this view and indicated an interest in supporting further study in this area (19).

Background

Simulation

Simulation is not a new technique, having long been used by designers in many different respects. Simulating airplane flight in a wind tunnel, simulating weather conditions in a climatic hangar, or simulating cockpit conditions in an aircraft simulator are but a few of the ways simulation has aided designers. Essentially, simulation is nothing more than setting up a model of a real world situation and then performing experiments on the model (18:2).

While there are many different applications for simulation, there are three situations for which it is most appropriate. First, it can be used when it is not possible to observe a process in the real world. It can also be used when the cost of experimenting with a real world situation is prohibitive. Finally, simulation must be used when the observed system is made up of so many interacting variables that a mathematical formulation of the system is not practical (18:7).

The ultimate purpose of any simulation is to answer the "what if" questions about complex situations (18:4). The degree to which these answers can be relied upon is dependent upon the degree to which the output of the model corresponds to the behavior of the real world system. Therefore, it is desireable to determine how well the output of the model corresponds to the real world before using the model as an analytical tool.

The two most appropriate tests for validating simulation models are: (1) to examine how well the values of the indigenous variables arrived at through simulation compare with known historical data, and (2) to determine if the simulation model's predictions of the behavior of the real system in future time periods is accurate (18:40). The second method is most useful on models dealing with relatively short-time horizons, while the first is applicable only when historical data is available.

Early Research

Considerable research effort has been expended by the RAND Corporation in attempting to develop a computer simulation device to model the aircraft and maintenance scheduling process, and to predict the outcomes of particular aircraft and maintenance schedules (3; 4; 15; 16). In 1965 Philip J. Kiviat, of the RAND Corporation studied the development of a computer program for planning and scheduling a particular class of maintenance actions known as scheduled maintenance. In this study, Kiviat suggested that a computer program could be used to determine how different flying schedules would impact maintenance capabilities. He further stated that such a program could then be used as a simulation device so that the computer, rather than the air base, would be the test bed for proposed scheduling innovations (15:25).

Later studies by the RAND Corporation incorporated unscheduled maintenance prediction into the models and greatly improved their predictive capabilities (16:v). As a result of these research efforts, it is clear that the computerization of the maintenance scheduling process is a feasible alternative to existing methods (5:9).

Recent Research

In a recent study, Berman compared the scheduling efforts of several Strategic Air Command wings (3; 4). Berman found that there was room for significant improvement in resource allocation if a more efficient means of scheduling air crews and aircraft could be found (3:ix). Several factors that contributed to schedule inefficiencies were identified. The data needed by schedulers is either nonexistent or not readily available. Time to examine alternative schedules is very limited. The trade offs made in the maintenance-operations negotiations are not based on any valid performance measures (3:iv).

Berman identified some sixty-one factors that should be taken into consideration when developing alternative schedules (3:74). The need to examine many different schedules, each combining all the factors in some unique way, suggested a need for a computerized scheduling system (3:79). The computer system proposed by Berman, and later developed by the RAND Corporation, was known as Decision Oriented Scheduling System (DOSS) (5:11).

The purpose of DOSS is to produce alternative flying schedules based on aircraft and maintenance parameters and maintenance scheduling policies. Numerous flying schedules are possible depending on the particular scheduling policies applied. If a difference in mission effectiveness occurs as scheduling policies are varied, the policies resulting in the highest mission effectiveness should be selected, provided that aircraft and maintenance parameters are held constant (5:11).

The most desireable way to evaluate alternative schedules would be through computer simulation (5:14). A computer simulation could simulate the execution of the flying schedule, complete the associated maintenance actions, and generate a simulated scheduling effectiveness. The flying schedule with the highest scheduling effectiveness could be selected.

In recent years RAND Corporation has developed a number of simulation models which address the simulation of operation and support of weapons systems at Air Force bases. Among those developed by RAND are Base Operations-Maintenance Simulator (BOMS), Support-Availability Multi-System Operations Model (SAMSOM), and Planned Logistics Analysis and Evaluation Technique (PLANET) (12:2). However, each of these models have design characteristics that facilitate study of some particular base function, which usually constrains their use to that particular function. As a result, the scope of each is too narrow for a general simulation of a flying schedule. RAND was also involved in the development of another model which does have the capability for simulating flying programs, the Logistics Composite Model (LCOM) (5:14).

Logistics Composite Model

The Logistics Composite Model is the result of a joint research effort initiated by Air Force Logistics Command (AFLC) and the RAND Corporation in November 1966 (12:4). The objective of this study was to develop a simulation model that could forecast required maintenance manning levels to support given flying hour programs. As such, LCOM was designed to simulate an actual wing flying operation. Support resources, including people, parts, facilities, and equipment, are utilized by the model to determine how shortages of any of the resources affect the overall operational status of the unit (23:1-4). A description of the general operation of the model is given in Appendix A.

A unique feature of LCOM is its flexibility, which permits almost any level of operations to be studied. Research efforts utilizing LCOM include the Yates and Fritz adaptation of LCOM to evaluate manpower requirements in support of the DC-130H aircraft, as well as DeGovanni and Douglas' use of LCOM to determine manning levels for a peacetime

F-15 operation (27;7). Glad and Pierce utilized LCOM to compare selected scheduling heuristics, as did Duncan and Gwaltney (13:11). Boyd and Toy evaluated LCOM's capability as an evaluation tool for weekly flying schedules, and concluded that it was not an accurate predictor of the actual wing scheduling effectiveness measured on a weekly basis. They did, however, find a significant relationship between the total number of sorties simulated over a six-month period and the actual number achieved by a wing during the same amount of time (5).

The range of topics covered by these studies indicate the inherent flexibility designed into LCOM. While the model was initially designed to develop maintenance manpower requirements, its value in other areas of study is evident. Because of its flexibility, and its ability to simulate a wing operation, it appeared that LCOM could serve as an effective tool for evaluating alternative monthly flying and maintenance schedules.

Objective

The objective of this research was to determine if the Logistics Composite Model could be effectively used to evaluate the alternative monthly flying and maintenance schedules of an F-15 wing.

Research Hypothesis

The research hypothesis established for this study is that a strong positive relationship exists between the LCOM simulated monthly sortie effectiveness and the actual monthly sortie effectiveness of an F-15 wing.

CHAPTER II

METHODOLOGY

Introduction

Once the problem had been identified and the objective of the research effort established, the next step was to determine where the sample would be drawn from and how the research hypothesis would be tested. The following discussion presents an outline of the sample selection procedure, defines the variables used by the study, and specifies the method used to test the research hypothesis.

Description of the Population and Sample

LCOM requires the user to supply a maintenance data base network[1] based on either a peacetime or wartime operation. The fact that only peacetime flying schedules were available as a sample for this study, made it necessary to obtain a network based on a peacetime operation.

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[1]A maintenance data base network includes all of the maintenance tasks necessary to model a wing maintenance environment. A separate data base is required for each aircraft type.

At this point in time, the only peacetime network available was designed for the F-15 aircraft. Tetmeyer recommended using the network because he had assisted in developing it, and knew the data base was available (20). The Director, Manpower and Organization, Deputy Chief of Staff, Plans, Headquarters, Tactical Air Command, granted authority to use the network, (14) and a copy was obtained from First Lieutenant James R. Lowell, USAF, 4400 MES/OLAA, Wright-Patterson AFB, Ohio (17). Lowell currently maintains a master copy of the network.

Thus, the population of interest for this study included all F-15 aircraft monthly flying and maintenance schedules. The sample consisted of six monthly schedules from the 1st TFW, Langley AFB, Virginia, representing the time period from July 1976 to December 1976.

The 1st TFW is currently one of two wings in the United States possessing F-15 aircraft, the other being the 58th TFTW, Luke AFB, Arizona. Because the 58th TFTW is a training operation, it was felt the 1st TFW would be more representative of a stable, peacetime F-15 flying operation. For this reason, the 1st TFW provided the sample schedules for this study.

Defining the Variables

In order to test the capability of LCOM to predict sortie effectiveness, two independent variables were established: *the actual monthly sortie effectiveness achieved by the wing* and *the simulated monthly sortie effectiveness achieved by the LCOM simulations*. The methods used in computing the two variables are presented below.

Actual Sortie Effectiveness

The actual sortie effectiveness achieved by the 1st TFW was determined using the Monthly Maintenance Data Analysis Report for December 1976 (24). This report contained summaries for each of the six months of schedules selected for this study. The two measures of importance were the number of home station sorties scheduled and the number of home station sorties flown. The relationship used to calculate the actual sortie effectiveness is given in Equation 1.

$$\begin{matrix}\text{Actual Sortie} \\ \text{Effectiveness}\end{matrix} = \frac{\text{Home Station Sorties Flown}}{\text{Home Station Sorties Scheduled}} \times 100 \quad (1)$$

Simulated Sortie Effectiveness

The simulated sortie effectiveness was obtained directly from the Performance Summary Report

(PSR)[2] after each monthly simulation. The monthly simulations were accomplished after analyzing the sample schedules obtained from the 1st TFW and converting them into a format acceptable to the model. In addition to sortie effectiveness, the PSR also contains the number of sorties requested and the number of sorties flown, the two measures used to compute the sortie effectiveness. Equation 2 shows the relationship between these two measures.

$$\text{Simulated Sortie Effectiveness} = \frac{\text{Number of Sorties Flown}}{\text{Number of Sorties Requested}} \times 100 \quad (2)$$

Design-to-Test Research Hypothesis

The most appropriate statistical test for the existence of a relationship between two independent variables is parametric correlation analysis (6:542). However, there are several assumptions that must be satisfied before parametric correlation can be applied. The most critical assumptions are that the data must be of at least interval level, and the two variables must be distributed jointly bivariate normal. If any of the assumptions cannot be met, then nonparametric correlation techniques must be used.

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[2] A PSR is the main output of an LCOM simulation and presents summary statistics in six functional categories: operations, aircraft, personnel, shop repair, supply, and equipment (12:7).

Sortie effectiveness has been defined as the ratio of sorties accomplished to sorties scheduled, expressed as a percentage. Therefore, both simulated monthly sortie effectiveness and actual monthly sortie effectiveness are of at least interval level. However, because of the small sample size and the lack of data indicating a normal distribution, the two variables cannot be assumed to be distributed jointly bivariate normal.

An alternative to parametric correlation is a nonparametric technique known as rank correlation. The only criteria that must be met to use rank correlation is that the two variables be of ordinal level or higher. A widely used measure of correlation between ranked series is Spearman's coefficient of rank correlation, denoted as r_s (6:554).

To apply Spearman's coefficient, the data to be correlated is arrayed in paired columns and ranked from lowest to highest. The sum of the squares of the differences in rank of the pairs is computed, and then used to calculate the coefficient as defined in Equation 3 (6:554).

$$r_s = 1 - \frac{6\Sigma d_i^2}{n(n^2-1)} \qquad (3)$$

where: d_i = Difference in rank between paired items in a series.

n = Number of pairs of ranked items in a series.

Research Hypothesis

The variables to be tested were the simulated monthly sortie effectiveness and the actual monthly sortie effectiveness. The simulated sortie effectiveness was defined as a random variable x, and the actual sortie effectiveness was defined as a random variable y. The following method was designed to test the research hypothesis.

Test

Using the coeffiecient of rank correlation calculated by Equation 3, a formal hypothesis test was conducted to determine if the relationship between x and y was significant. A critical coefficient of correlation (r_c) was determined from statistical tables (6:851) at the 0.95 level of significance and four degrees of freedom. The following hypothesis was established:

H_0: $\rho_{xy} < 0$ (implies no positive relationship)

H_1: $\rho_{xy} > 0$ (implies a positive relationship does exist)

Decision Rule: $r_s > r_c$ reject null hypothesis.

If the null hypothesis is not rejected, it would indicate that LCOM could not successfully predict the monthly sortie effectiveness of an F-15 wing, based on this sample. A further conclusion would be that LCOM is not a feasible model for evaluating alternative flying schedules.

Rejection of the null hypothesis would establish LCOM as a predictor of monthly sortie effectiveness for an F-15 wing, based on this study. It would also indicate that LCOM has the potential to be used for evaluating alternative monthly flying and maintenance schedules.

Summary List of Assumptions

The following assumptions were made in this study:

1. The F-15 maintenance data network used, actually represents an F-15 wing.

2. The data obtained from the 1st TFW is accurate.

3. Sortie effectiveness, as defined, is at least interval level data.

Summary List of Delimitations

The following delimitations apply to this study:

1. The limitations inherent to the Logistics Composite Model are necessarily reflected in the results of this study.

2. As only F-15 aircraft monthly schedules were used in this study, no attempt will be made to generalize any results to any other aircraft type.

3. The F-15 maintenance data network used has not been updated since its development, nor has it been validated in a field study.

CHAPTER III

MODEL OPERATION

Introduction

In order to perform the LCOM simulations and test the research hypothesis several tasks had to be accomplished. The first, model selection, involved determining which version of LCOM to use. Since its development in 1966, numerous changes and updates have been made to the original LCOM. Several different agencies now have separate versions with unique features. It was necessary, therefore, to select the model which would be most useful in this study.

Once the model had been selected, the maintenance data base network, used to describe the maintenance tasks of an F-15 TFW to LCOM, had to be altered to insure compatibility between the network and the model. This consisted primarily of input format changes which are discussed below. After the necessary changes had been made, the network was ready to be input into the main simulation program.

The other input required by the main program is the user designed flying schedule. Using the monthly and weekly flying and maintenance schedules obtained from the 1st TFW, a simulated monthly flying schedule was created for each of the six months of the sample. The main LCOM simulation program could then be executed.

The following discussion gives the rationale behind the model selection, the changes required to the maintenance network, the procedures used to create the monthly flying schedules and, finally, how the main simulation programs were run.

Model Selection

Most of the changes made to the original LCOM have involved either adding a new feature, or changing the manner in which the data could be input to the model. However, a major change occurred in June 1977, when a new version of the model was released, known as LCOM II. LCOM II represents a significant improvement over the previous versions because of the improved diagnostics, the increased accuracy of results on long simulations, and the added flexibility it incorporates (10). LCOM II is written in SIMSCRIPT II.5, whereas the original version is written in SIMSCRIPT I.5(22).

Initially, this study used the older version of LCOM because LCOM II had not been released. After its release in June, however, Drake recommended using LCOM II because no further support would be provided to users of the older version (10). For this reason, and because only minor changes were required to adapt to it, LCOM II was selected for use in this study.

Conversion of the Maintenance Data Network

The maintenance data base used in this study was designed to model all the maintenance actions required to maintain a typical wing of F-15 aircraft engaged in a peacetime flying operation. This was accomplished by modeling in detail each of the major functions performed by the wing maintenance personnel. The functions modeled include such things as preflight, thruflight, postflight, washing and phase inspection of aircraft. The detailed model of each funtion contains all the tasks required to accomplish the function. The description of each task includes the parts required, the personnel needed, any facilities or aerospace ground equipment required, and the expected time required to complete the task. The tasks describe both scheduled and unscheduled maintenance actions with probability distributions and failure clocks being used to generate random failures of aircraft components. A simplified graphical representation of the task network used to model the wash function is presented in Figure 1.

In this simple network, the tasks to be completed are towing, removing and replacing inspection panels,

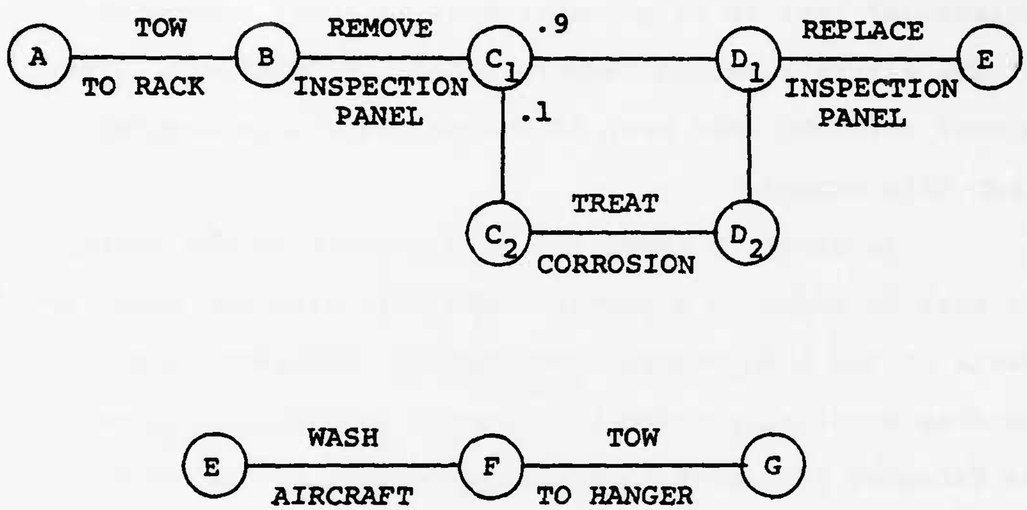

Fig. 1. Simple Task Network

washing the aircraft and treating corrosion. A description of the towing task would show that it requires a tug, an operator, and would take, on the average, twenty minutes to accomplish. It should also be noted in the network that the probability of occurrence of the "treat corrosion" task is 10 percent; that is, only one-tenth of the aircraft washed require corrosion treatment. The actual networks used are, of course, much more complex than this example.

In order to input the task network to the model, it must be coded in a format compatible with the requirements of the LCOM preprocessor model. DeGovanni and Douglas originally coded the network in a format known as Extended 11, which is a unique feature of the Aeronautical Systems Division's (ASD) version of LCOM (7). For a complete description of Extended 11 format, see Tetmeyer (21). Prior to use in this study, the network had to be converted into standard LCOM format. Either of the Drake references contains descriptions of standard LCOM format (8; 9). The conversion was accomplished by initially processing the data through three utility programs maintained by ASD before generating a card deck coded in standard LCOM format. Figure 2 represents a block diagram of this process.

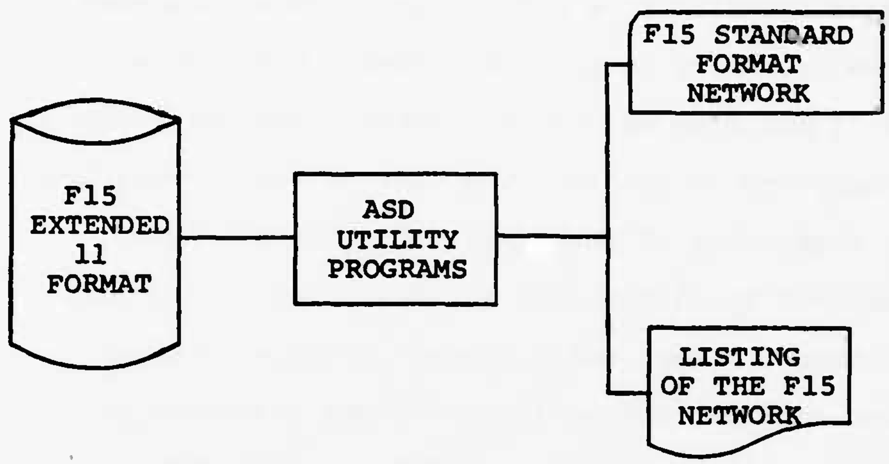

Fig. 2. Conversion of the Maintenance Data Network

The card file, which consisted of approximately 5,000 cards, was then placed on a permanent CREATE[1] disk file known as NETWORK, as depicted in Figure 3.

Once the disk file NETWORK had been established, the changes necessary to make the network compatible with LCOM II could be made from a CREATE terminal. The changes consisted of removing the task network describing the phase inspection of the TF-15, changing all task times described as distributed log-normal with zero variance to constant times, modifying miscellaneous report description entries, and setting manpower resources to the levels authorized for the 1st TFW. Parts, supplies, and facilities were not constained, but were used with the quantities established in the networks. Appendix B lists the detailed changes to the F-15 maintenance data network file that were required to perform this study. After all changes, deletions and additions had been made the file NETWORK was stored for later use in the main simulation program.

Creation of the Monthly Flying Schedules

In addition to the maintenance data network, the main LCOM simulation program also requires a flying scenario defined by the user. In the flying scenario the

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[1] CREATE is the computer system maintained by AFLC Headquarters at Wright-Patterson AFB OH. All computer operations in support of this study were accomplished on the CREATE system.

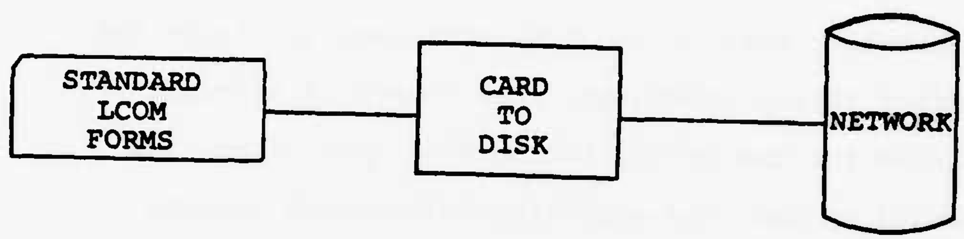

Fig. 3. Creation of the File Network

user requests LCOM to simulate the maintenance actions required to perform a given series of flying missions and routine scheduled maintenance tasks. As the objective of this study was to evaluate LCOM's ability to predict monthly sortie effectiveness, the flying scenario input to the main simulation attempted to model as closely as possible the monthly flying and maintenance schedules received from the 1st TFW.

The monthly schedules obtained from the 1st TFW contained most of the data necessary to create the simulated flying schedules. The number of aircraft available for the month, the total number of sorties scheduled by day, and scheduled maintenance actions, such as aircraft phases and washes, were included in the monthly schedules. However, such factors as number of aircraft per mission, and aircraft takeoff times, were not included. For this reason weekly flying and maintenance schedules for the same time period, which included the necessary information, were used to supplement the monthly schedules to form the basis for creating the simulated monthly flying and maintenance schedules.

It was intended that all the flying and scheduled maintenance actions performed by the 1st TFW at home station during the period 1 July 1976 to 31 December 1976 be simulated in this study. The simulated monthly flying and maintenance schedules created for input to LCOM contained the same types of sorties as those actually flown by the 1st TFW. Also, washing and phase inspections were scheduled as indicated in the 1st TFW monthly schedules. In addition, dummy sorties, requiring no resources except aircraft and no maintenance actions, were scheduled to insure that the number of aircraft available for executing the simulated flying schedule was equivalent to the number available to the 1st TFW when the comparable schedule was actually flown.

When each monthly schedule had been created the total number of sorties requested by month was computed. This total was then compared to the actual number of sorties scheduled for that given month as reported on the Monthly Maintenance Data Analysis Report for December 1976. If a difference existed between the two figures, sorties were either added or deleted to the simulated schedule until the number requested matched the actual number on the analysis report. This step insured the number of sorties requested in each simulated monthly flying schedule matched what the wing had actually scheduled. Appendix C gives an example of a simulated monthly flying schedule, and outlines how the various parameters were established.

After this step had been accomplished, the schedules were coded onto general purpose data sheets in the format required by LCOM. Each monthly schedule was then key punched into a separate card deck. These card files were then read into the CREATE System onto permanent disk files. A separate disk file was established for each month. Figure 4 gives a block diagram of this process using the month of July as an example.

Operation of the Main Simulation Model

The maintenance data network and simulated monthly flying schedules served as the input for the main LCOM simulations. The main simulations were accomplished in three steps: production of the initialization tape, production of the exogenous events tapes, and running of the main model. The detailed instructions and job control cards required for each step are given in Appendix D. A general description of each step is given below.

Production of the Initialization Tape

The production of an initialization tape was necessary in order to translate the maintenance data file, NETWORK, into a form suitable for use in the main model. This required processing the file, NETWORK, through the preprocessor portion of LCOM. The

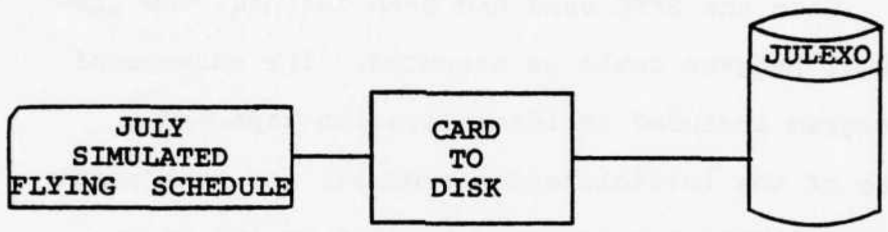

Fig. 4. Creation of a Simulated Monthly Flying Schedule

preprocessor portion also required another input, called a SPEC card. A SPEC card controls the level of information on the initialization listing and assigns file codes to specific files used during the simulation. A detailed discussion on the use of the SPEC card can be found in Reference 22.

Once the SPEC card had been defined, the preprocessor program could be executed. The outputs of the program included an initialization tape and a listing of the initialization program. At this point, the initialization tape could be read by the main simulation. Figure 5 depicts this process in block form.

Production of the Exogenous Events Tapes

In addition to the initialization tape, the main model requests an exogenous events tape. The purpose of producing exogenous events tapes is to translate the monthly flying schedules into a format acceptable to the main model. A total of six tapes was produced, one for each month. The same procedure which is described below for the month of July, was followed for the other five months.

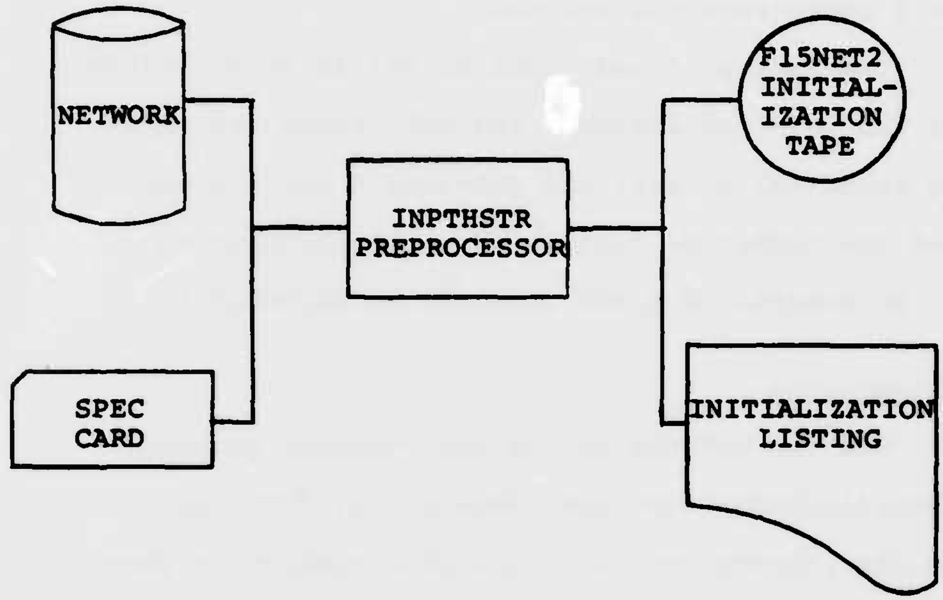

Fig. 5. Production of the Initialization Tape

The main input required to produce the exogenous events tape was the disk file, JULEXO (simulated monthly flying schedule for July). A SPEC card was again required, and both inputs were entered into the Sortie Generator portion of the preprocessor program. The output of the program consisted of an exogenous events tape, JULEXO, and a Mission Summary Report (MSR). Figure 6 represents the process.

The tape produced, JULEXO, was saved for later use in the main simulation. The MSR listed the input flying schedule, by day, and provided a monthly summary of the number of sorties requested by mission name. An example of a MSR is given in Appendix C.

Main Simulation

The two outputs of the preprocessor program, the initialization tape and exogenous events tape, became the primary inputs to the main simulation program. A SPEC card was also needed, and an additional file, known as a Run Specification File (RSF), had to be created.

The purpose of the RSF was to input the random seeds[2], control the frequency of the Performance Summary

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[2] Random seed is a number used to initialize the random number generator which supplies the random number draws for use with probability tables and failure clocks.

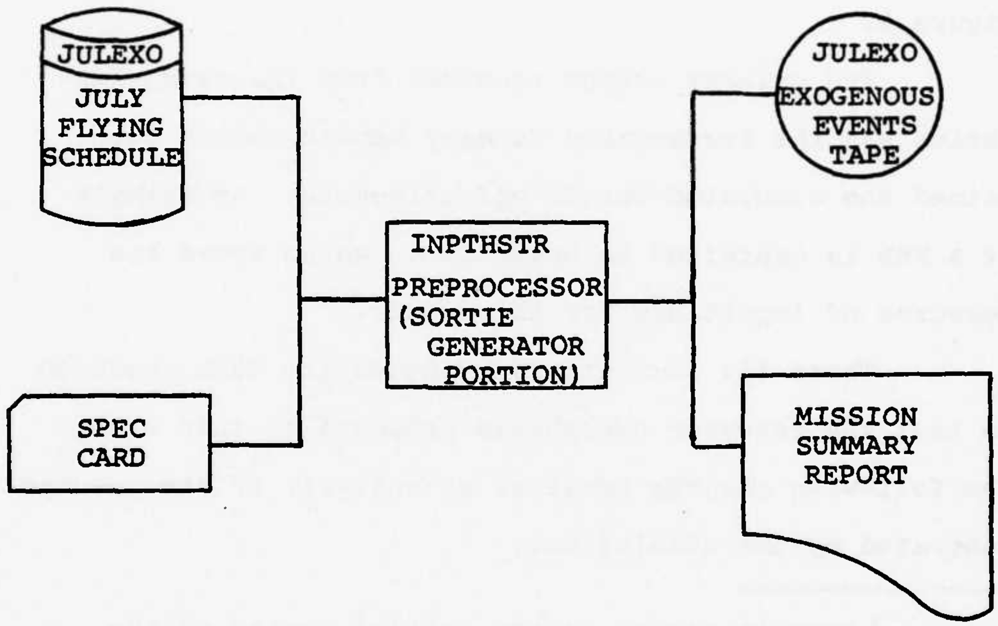

Fig. 6. Production of the Exogenous Events Tape

Report and the length of the simulation, and to specify the length of the burn-in period.[3] The entries to this file were prepared in accordance with the layouts given in the LCOM II reference (22). The specific values used are given in Appendix D.

Once the RSF had been created, the main simulations were executed. The process is depicted in Figure 7.

The primary output received from the main simulation was the Performance Summary Report, which contained the simulated sortie effectiveness. An example of a PSR is contained in Appendix E, which shows the measures of importance for this study.

These six simulations produced the data required to test the research hypothesis proposed by this study. The following chapter presents an analysis of the results generated by the simulations.

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[3] Burn-in period is the initial period of the simulation when results may not be valid because of the way the data are initialized. It allows the simulation to "settle down" and attain a steady operation (12:61).

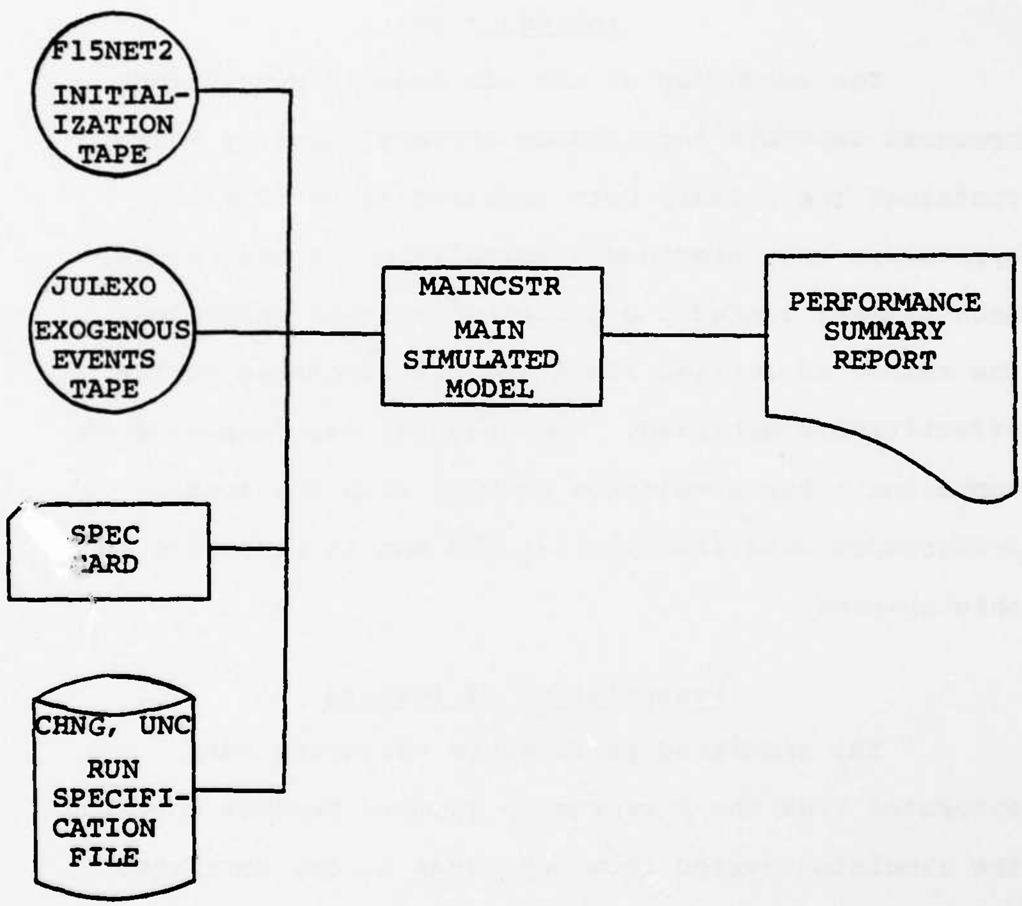

Fig. 7. Operation of the Main Model

CHAPTER IV

ANALYSIS AND RESULTS OF SIMULATION

Introduction

The execution of the six monthly simulations produced separate Performance Summary Reports, which contained the primary data required to perform the hypothesis test previously established in this study. Each summary listed the number of sorties scheduled, the number of sorties flown and the simulated sortie effectiveness achieved. The analysis was completed by comparing these simulation results with the actual performance data from the 1st TFW and is presented in this chapter.

Presentation of Results

The simulated performance variables were extracted from the Performance Summary Reports covering the simulated period from day seven to day forty-two for each month simulated. The first seven days of each simulation constituted the burn-in period and were disregarded. Although the simulated flying schedules for days seven to forty-two contained scheduled sorties for only one calender month, either thirty or thirty-one days, the model had to be run to the next higher multiple of seven to obtain a PSR for the entire period. The results of the simulation are summarized in Table 1.

The actual performance variables were extracted from the Monthly Maintenance Data Analysis Report published by the 1st TFW for December 1976 (24). The data values represent the actual number of home station sorties scheduled and flown by the 1st TFW during the period covered by this study. The actual results achieved by the wing are presented in Table 2.

Test of the Research Hypothesis

Prior to the test of the research hypothesis the Spearman's Rank Correlation Analysis was performed to develop the sample statistic, r_s. The results presented in Tables 1 and 2 were arrayed and the sample statistic computed in accordance with the methodology described in Chapter II. The computation of r_s is shown in Table 3.

As stated in the methodology section, a one-tailed test at the .95 level of significance, with four degrees of freedom, was used to test the research hypothesis. The hypothesis is restated below and the significance test is performed.

H_o: $P_{xy} < 0$ (implies no positive relationship)

H_o: $P_{xy} > 0$ (implies a positive relationship does exist)

TABLE 1

SIMULATED PERFORMANCE

Month	Simulated Sorties Requested	Simulated Sorties Flown	Simulated Sortie Effectiveness
July	434	373	85.94%
August	733	585	79.81
September	895	485	54.19
October	878	573	65.26
November	739	531	71.85
December	905	731	80.77

TABLE 2

ACTUAL PERFORMANCE

Month	Actual Sorties Requested	Actual Sorties Flown	Actual Sortie Effectiveness
July	434	405	93.32%
August	733	673	91.81
September	895	815	91.06
October	878	745	84.85
November	739	613	82.95
December	905	732	80.88

TABLE 3

SUMMARY OF STATISTICAL COMPUTATIONS

Month	X_i	R_{X_i}	Y_i	R_{Y_i}	d_i	d_i^2
July	85.94	6	93.32	6	0	0
August	79.81	4	91.81	5	1	1
September	54.19	1	91.06	4	3	9
October	65.26	2	84.85	3	1	1
November	71.85	3	82.95	2	1	1
December	80.77	5	80.88	1	4	16
						28

$$v_s = 1 - \frac{6\Sigma d_i^2}{n(n^2-1)} = 1 - \frac{(6)(28)}{(6)(36-1)} = .2$$

where:

X_i = The simulated scheduling effectiveness for month i;

R_{X_i} = Rank of X_i, ranked from lowest to highest;

Y_i = Actual scheduling effectiveness for month i;

R_{Y_i} = Rank of Y_i, ranked from lowest to highest;

d_i = The absolute value of the difference between X_i and Y_i; and

n = Number of ranked pairs.

Decision Rule: $r_s > r_c$, reject null hypothesis

$r_s = .2 < r_c = .829$, cannot reject the null hypothesis

Because $r_s = .2$ was not greater than the critical value $r_c = .829$, the null hypothesis could not be rejected. Therefore, it cannot be concluded that a positive relationship exists between the LCOM simulated sortie effectiveness and the actual sortie effectiveness of an F-15 Monthly Flying and Maintenance Schedule.

Analysis of Results

The failure to show a positive relationship could have resulted from several factors beyond the control of this study. The limited time available does not permit a complete exploration of all these factors, but some of the more apparent potential factors are presented below.

One possible factor affecting the results is that the 1st TFW had not achieved a steady, on-going operation at the time the data were collected for this study. The F-15 maintenance data network used in this study was designed to represent a wing operating under constant conditions with aircraft which had matured past the break-in period. The 1st TFW was receiving new aircraft throughout the period covered by this study. Thus, the network used may not have been truly representative of the 1st TFW during the period covered by this study.

A second potential factor affecting the outcome of this study was the large variance between the number of sorties scheduled in the monthly flying schedule and the number actually scheduled during the month. The number of sorties that had to be added to some of the months to bring them in line with the number of home station sorties scheduled, as shown on the Monthly Maintenance Data Analysis Report, may have been so large that non-representative simulated monthly flying schedules resulted. The adjustment required for each month is given in Table 4.

Finally, it is possible that LCOM, which was designed to study manning and resource allocation, is simply not capable of predicting sortie effectiveness. There may be some dynamic factors in an actual wing operation, which because of their stochastic nature, cannot be incorporated in either the network or the LCOM model. This could include such factors as morale, knowledge and experience level of the assigned maintenance personnel and the management action taken by local managers.

TABLE 4

ADJUSTMENTS TO THE MONTHLY SCHEDULE

Month	Sorties Scheduled in Monthly Schedule	Sorties Actually Scheduled During Month
July	407	434
August	687	733
September	487	895
October	798	878
November	914	739
December	1049	905

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The objective of this research effort was to determine if the Logistics Composite Model had the capability to predict the monthly sortie effectiveness of a F-15 flying and maintenance schedule. A significant amount of a wing's available resources are dedicated to maintaining and flying aircraft, and it was felt that a means for evaluating alternative schedules might result in more efficient use of these resources. Although this was not the original purpose for which LCOM was designed, it appeared the model might have the capability to be used as an evaluation device.

In order to evaluate the model's capability, a test was designed based on six monthly flying and maintenance schedules obtained from the 1st TFW, Langley AFB, Virginia. These schedules were used to create six simulated monthly schedules, which were then simulated in LCOM. The simulated results were obtained and compared to what the wing had actually achieved during the six months in question.

A statistical test was then performed to determine if a positive relationship existed between the two measures. The result of this test was that there was no relationship between the sortie effectiveness achieved by an LCOM simulation and the actual sortie effectiveness achieved by the wing. Failure of the test resulted in the following conclusions.

Conclusions

The research hypothesis of this study was that a strong positive relationship existed between LCOM simulated monthly sortie effectiveness and the actual monthly sortie effectiveness of an F-15 wing. Based on the failure to be able to reject the statistical hypothesis that no positive relationship exists, it must be concluded that LCOM cannot accurately predict the monthly sortie effectiveness of an F-15 wing.

A further conclusion is that LCOM is not a feasible means of evaluating alternative F-15 monthly flying and maintenance schedules. The lack of a positive relationship between simulated sortie effectiveness and actual sortie effectiveness would make the results achieved from an LCOM simulation unacceptable for the purpose of comparison.

The final conclusion of this study is that an evaluation device for monthly schedules would be of little value, if the data received from the 1st TFW is representative of other F-15 wings. The great difference between the number of sorties scheduled in the monthly schedule and the actual number of sorties scheduled during the month indicates that the monthly schedule is used mostly as a guide, and not as a hard and fast schedule. If this is the case, evaluation of schedules would be meaningless because the schedule selected may, or may not, be the one actually flown.

Recommendations

As stated above, it is felt that the monthly flying and maintenance schedule is used mostly as a guide by F-15 wings. Therefore, any further studies attempting to evaluate LCOMs capability to predict monthly sortie effectiveness may experience some of the same problems that occurred in this study. The authors feel a weekly flying and maintenance schedule might be a better basis for evaluating LCOMs predictive ability, as a wing adheres much more closely to a weekly schedule.

A further recommendation concerns studies using LCOM simulated sortie effectiveness as the decision variable. The failure to show any relationship between simulated sortie effectiveness and actual sortie effectiveness suggests that the simulated sortie effectiveness may not be truly representative of what a wing actually achieves. For this reason, it is recommended that any LCOM studies using sortie effectiveness as the decision variable insure that the maintenance data base network being used is valid, and actually represents the environment being modeled.

APPENDIXES

APPENDIX A

GENERAL DESCRIPTION OF LCOM

The Logistics Composite Model consists of several complex and interrelated computer programs. While a complete understanding of these programs is not necessary, the user should be familiar with how the programs interface. The following discussion, extracted from The Logistics Composite Model: An Overall View (6), is intended to provide a general backgrcund on the operation of LCOM.

The LCOM simulation package consists of three separate computer programs: a preprocessor program, a main or simulation program, and a postprocessor program. Figure 8 shows how these programs interrelate in the operation of the model. The preprocessor prepares the data for use by the simulation program. The simulation program combines the user-defined task networks with the user-defined schedule of events to produce a simulation. The postprocessor analyzes and prints the data associated with the simulation.

Preprocessor Program

The two primary inputs to LCOM are the task networks and the event schedules. The task networks, or maintenance data base, represent the scheduled and unscheduled maintenance procedures required to

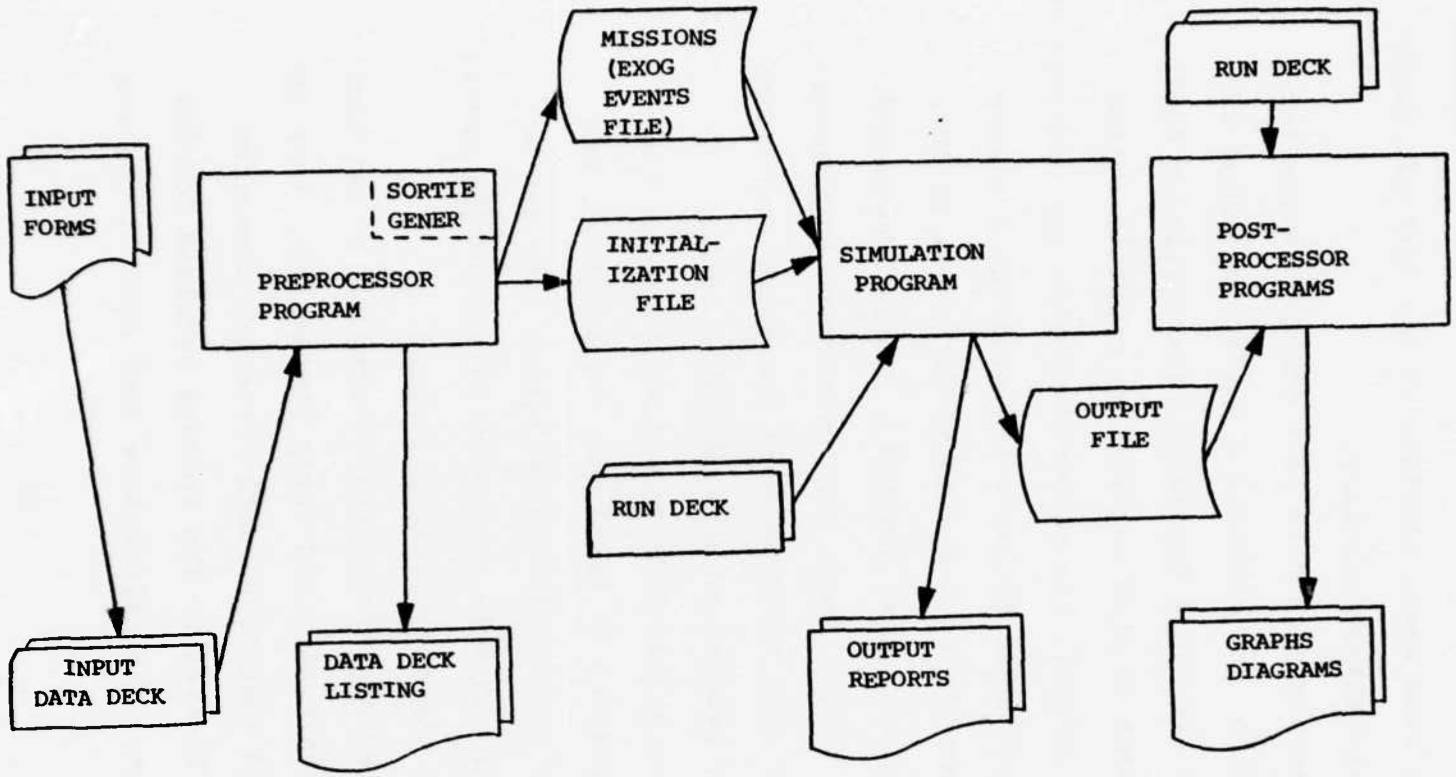

Fig. 8. Overall Structure of Logistics Composite Model

support a particular aircraft type. The event schedule, or operations data base, consists of the aircraft daily flying and maintenance schedule.

The maintenance data base networks serve two purposes. First, the networks specify the number of personnel (by Air Force Specialty Code), support equipment, and amount of time required to complete maintenance tasks. Second, the networks provide the probability of aircraft component failures and associated repair times. Failure clocks are used to determine failure times and the user must provide a failure frequency rate for each clock. Mean sorties between maintenance actions is the most commonly used parameter, but other parameters not related to sorties can be used.

The operations data base specifies the time and type of missions to be flown. In addition, the mission length and mission cancellation time can be specified. This data is processed by the sortie generator portion of the preprocessor program.

The preprocessor program accomplishes two functions: data conversion and error processing. Both the maintenance and operations data bases are converted from the user formats to the formats required for the main simulation. The maintenance data base is checked for consistency and completeness. If any ambiguous conditions or errors are discovered an error notice is output.

Main Program

The main simulation model, using the task networks produced from the maintenance data base and responding to the mission requirements generated from the operations data base simulates a broad range of aircraft operation, scheduling, maintenance, and supply functions at an Air Force Base. For each mission requirement, the program internally controls the processing of each aircraft toward completion of the mission.

The model attempts to complete all missions. However, cancellations can result from unavailability of sufficient aircraft to schedule into presortie processes or the loss of aircraft to unscheduled maintenance according to failures detected in presortie tasks.

The program also attempts to simulate all maintenance and supply actions. After each sortie, the aircraft undergoes flight line maintenance and any assemblies that have failed are sent to shop maintenance or the depot for repair. Nonreparable items are drawn from supply, if available. Replacements for reparable items are drawn from serviceable stock, and when the reparable item has been repaired it is returned to the serviceable stock. When all actions necessary to make the aircraft operationally ready have been completed, it will be placed in the available aircraft pool.

In addition to the maintenance data base and operations data base, the simulation requires run specification data and embedded decision model input data. The run specification data establishes the run identification number and frequency of status reports.

The primary output of the main simulation program is the Performance Summary Report. This report provides sixty-five overall performance statistics divided into six functional groups: operations, aircraft, personnel, shop repair, supply, and equipment. These statistics are produced at user-specified intervals and level of detail. In addition, other reports are available if requested in the run specifications.

Postprocessor Program

The purpose of the postprocessor program in LCOM is to produce selected summary statistics covering the entire simulation period. The main simulation program produces the main summary statistics, but in order to interpret the overall results of the simulation, the postprocessor reports should be studied.

Specifically, the postprocessor program produces, two output reports. These are the summary statistics and the aircraft displays, both in graphical form.

Summary statistics are normally displayed as a function of simulated time. In this manner, the user may view such things as percentage of sorties accomplished, average aircraft turnaround time, personnel utilization percentage, and other selected topics. Thus, changes that occur over the simulated time period are readily apparent.

An aircraft display is a plot of the various tasks incurred during the simulation for a selected aircraft. It shows not only the tasks involved in fixing the aircraft, but also any shop repair actions on components removed from the aircraft. The displays are useful in verifying that the simulated events represent real world situations. However, because the displays are for randomly selected aircraft, they should not be a basis for overall conclusions about the simulation.

For a more detailed overview of LCOM the reader is referred to Drake (9) or Tetmeyer (21).

APPENDIX B

CHANGES TO THE MAINTENANCE NETWORK

There were two basic reasons for changes to the maintenance data network. First, the card deck of the network obtained from Lowell had to be made compatable with the version of LCOM used on CREATE. Second, the network had to be modified for use with LCOM II.

The maintenance data network was established as a permanent disk file in Binary Coded Decimal (BCD) format without line numbers. When changes were to be made the utility program BCDASC was used to convert the file into Standard ASCII format, with line numbers, for use with the Time Sharing System (TSS) on CREATE. All changes were effected using TSS and the text editor program available on CREATE. When the changes were completed the utility program ASCBCD was used to remove line numbers and convert the network back into BCD format required by LCOM. For a detailed discussion on the use of the text editor and the programs ASCBCD and BCDASC the reader is referred to Abbott (1).

The data network was maintained in Standard LCOM format throughout this study. The standard format, of records making up the data network, is prescribed by a series of LCOM forms. The specific record layouts of the LCOM forms are given by Drake (9). The changes made to the data network is given below by standard LCOM form number.

Form 10. Form 10 is used to control the report heading on the Performance Summary Report. There were two changes to the form 10. The report headings relating to the TF-15 had to be deleted and the number of report headings used for parts had to be reduced to less than ninety-nine.

Form 11. Form 11, used to define the task networks, required only one modification. The task network associated with phase inspection of the TF-15 was removed.

Form 12. Form 12, used to define the resources required and time duration for each task, required three changes. First, the tasks requiring the TF-15 were deleted. Second, tasks which consumed a part, and required manpower or air ground equipment, had to be modified to require only the consumable part. This second change was to make the network compatible with the cannabalization routines in LCOM II. The final change was to alter tasks whose durations were established as distributed log-normal with a zero variance to tasks with constant duration. The original LCOM would permit a log-normal distribution with zero variance, but LCOM II would not.

Form 13. Form 13, used to establish resource quantities and identify which column heading to report activity under, had to be modified for two reasons. First, the TF-15 had to be eliminated. Second, the report columns on the parts had to be changed to agree with the altered headings established on the form 10.

Form 14. Form 14, used to identify failure clocks, required only one change. The failure clock associated with the TF-15 phase inspection was deleted.

Form 16. Form 16 is used to define the shift policies and manning levels. Although this form initially set all manning at 200 people per shift, this number was altered to set manning at the authorized level established for the 1st TFW at the time of this study.

Form 17. Form 17, used to identify the entry nodes associated with each mission name, required two changes. First, the five mission names used by the TF-15 were removed. Second, a conversion configuration class and the type aircraft associated with each mission name had to be added to all form 17s.

Form 19. A form 19 had to be added to the network to specify the search pattern to be used to obtain aircraft for scheduled sorties.

APPENDIX C

MONTHLY FLYING SCHEDULES

1. The simulated monthly flying schedules were prepared using the wing monthly maintenance and flying schedules as a guide. This appendix contains a sample listing of one of the simulated monthly flying schedules and a portion of the Mission Summary Report generated by the sortie generator portion of the preprocessor.

2. Explanation of Mission Names appearing on the simulated monthly flying schedule and the Mission Summary Report:

a. PFLTF was a dummy mission used to make aircraft unavailable for flying. This mission was used to make the number of aircraft available to the model consistent with the number available to the 1st TFW.

b. AA2X designated Air-to-Air missions. The last digit signified the type of aircraft processing and the number of times an aircraft was to fly each day: one was preflight to thru flight, two was thru flight to thru flight, three was thru flight to postflight, and four was preflight to postflight.

c. PHASF was used to schedule aircraft for Phase Inspections.

d. WASHF was used to schedule aircraft for Washing and Corrosion Control Inspections.

3. Explanation of Column Headings on Mission Summary Report:

a. TIME--Daily simulation time at which model was notified of mission. This entry is obtained by subtracting the lead time from the take off time.

b. MISSION--Mission name.

c. A/C TYPE--Type of aircraft to be flown.

d. SCHED--Number of aircraft scheduled for a mission. This entry was based on the policies used in the weekly maintenance and flying schedules.

e. MIN--Minimum number of aircraft required to fly a given mission. A minimum of one was used for most missions.

f. SPARE--Number of space aircraft to be prepared. This entry was determined from the policies used in the Monthly Maintenance and Flying Schedules. If a spare was not used for a particular mission it remained available for subsequent missions.

g. PRIORITY--Specified the order of importance of a particular mission. All PFLTF, PHASF, and WASHF missions were given priority of one to insure 100 percent completion.

h. TAKEOFF--Scheduled take off time. Take off times were determined using the Weekly Maintenance and Flying Schedules as guides.

i. LATENESS--Amount of time mission may be delayed. If delayed exceeds lateness, the mission is cancelled. A constant of two hours was selected for mission cancellation based on discussions with Senior Master Sargeant Adams (2).

j. SORTIE LENGTH--Length of sortie in hours and minutes.

k. LEAD TIME--Length of time prior to take off that the model is notified of a mission. A constant of four hours was used for lead time based on the discussions with Senior Master Sargeant Adams regarding wing policies (2).

4. The first seven days of each monthly flying schedule were used as a burn-in period to permit the model to achieve steady state. The total period simulated had to be set to forty-two days in order to obtain a Performance Summary Report covering the entire calender month. However, no sorties were scheduled beyond the end of the calender month.

FORM 20 PROCESSING

20
LIST 42 JULEX0 JULY FLYING SCHEDULE
BEGIN 0.0
EX00 DATA FILE GENERATED FOR 42. DAYS. IDENT = JULEX0 JULY FLYING SCHEDULE

20	1	0600	F15	PFLTF	42	42	0	16.0	.1	N	4.0	2.0	1	1	42
20	1	0600	F15	PFLTF	2	2	0	16.0	.1	N	4.0	2.0	1	1	42
20	1	0600	F15	WASHF	2	2	0	2.5	.1	N	4.0	2.0	1	1	8
20	1	0600	F15	PHASF	1	1	7	2.5	.1	N	4.0	2.0	1	2	7
20	1	0755	F15	AA21	1	3	4	1.2	.1	N	4.0	2.0	2	1	9
20	1	0840	F15	AA21	1	3	0	1.2	.1	N	4.0	2.0	2	1	9
20	1	0845	F15	AA21	1	1	0	1.0	.1	N	4.0	2.0	2	1	9
20	1	0940	F15	AA21	1	4	0	1.2	.1	N	4.0	2.0	2	1	9
20	1	1010	F15	AA21	1	3	0	1.2	.1	N	4.0	2.0	2	1	8
20	1	1055	F15	AA21	1	2	0	1.2	.1	N	4.0	2.0	2	1	9
20	1	1325	F15	AA22	1	3	0	1.2	.1	N	4.0	2.0	2	1	9
20	1	1340	F15	AA22	1	3	0	1.2	.1	N	4.0	2.0	2	1	9
20	1	1410	F15	AA22	1	3	0	1.2	.1	N	4.0	2.0	2	1	9
20	9	1010	F15	AA24	2	3	0	2.0	.1	N	4.0	2.0	2		
20	9	0600	F15	PFLTF	1	1	0	16.0	.1	N	4.0	2.0	1	1	11
20	10	0600	F15	PFLTF	3	3	0	16.0	.1	N	4.0	2.0	1	1	12
20	10	0930	F15	AA24	2	2	1	2.0	.1	N	4.0	2.0	2		
20	13	0600	F15	PFLTF	2	2	0	16.0	.1	N	4.0	2.0	1	1	16
20	13	0600	F15	PHASF	2	2	0	2.5	.1	N	4.0	2.0	1		
20	13	0600	F15	WASHF	2	2	0	2.5	.1	N	4.0	2.0	1		
20	13	0740	F15	AA21	1	2	3	1.2	.1	N	4.0	2.0	2	1	16
20	13	0825	F15	AA21	1	4	5	1.2	.1	N	4.0	2.0	2	1	16
20	13	0845	F15	AA24	2	4	0	2.0	.1	N	4.0	2.0	2		
20	13	0930	F15	AA24	2	4	0	2.0	.1	N	4.0	2.0	2		
20	13	1240	F15	AA22	1	2	0	1.2	.1	N	4.0	2.0	2	1	16
20	13	1325	F15	AA22	1	2	0	1.2	.1	N	4.0	2.0	2	1	16
20	13	1510	F15	AA22	1	2	0	1.2	.1	N	4.0	2.0	2	1	16
20	14	0600	F15	PFLTF	0	0	0	16.0	.1	N	4.0	2.0	1	1	42
20	14	0600	F15	WASHF	1	1	0	2.5	.1	N	4.0	2.0	1		
20	14	0845	F15	AA21	1	4	0	1.6	.1	N	4.0	2.0	2	1	16
20	15	0600	F15	PHASF	1	1	0	2.5	.1	N	4.0	2.0	1		
20	16	0600	F15	WASHF	1	1	0	2.5	.1	N	4.0	2.0	1		
20	16	1555	F15	AA22	1	1	0	1.2	.1	N	4.0	2.0	2		
20	18	0600	F15	PFLTF	1	1	0	16.0	.1	N	4.0	2.0	1		
20	19	0600	F15	PHASF	1	1	0	2.5	.1	N	4.0	2.0	1	3	22
20	19	0740	F15	AA21	1	4	3	1.2	.1	N	4.0	2.0	2	1	23
20	19	0825	F15	AA21	1	2	0	1.2	.1	N	4.0	2.0	2	1	23
20	19	0845	F15	AA21	[illegible]	[illegible]	[illegible]	[illegible]	.1	N	4.0	2.0	2	1	23
20	19	0930	F15	AA21	1	3	0	1.6	.1	N	4.0	2.0	2	1	23
20	19	1240	F15	AA22	1	4	0	1.2	.1	N	4.0	2.0	2	1	23
20	19	1325	F15	AA22	1	2	0	1.2	.1	N	4.0	2.0	2	1	23
20	19	1510	F15	AA22	1	2	0	1.2	.1	N	4.0	2.0	2	1	23
20	21	0600	F15	WASHF	2	2	0	2.5	.1	N	4.0	2.0	1		
20	23	0600	F15	PFLTF	1	1	0	16.0	.1	N	4.0	2.0	1		
20	23	0740	F15	AA21	1	2	0	1.2	.1	N	4.0	2.0	2		
20	26	0600	F15	PHASF	1	1	0	2.5	.1	N	4.0	2.0	1	2	28
20	26	0740	F15	AA21	1	4	5	1.2	.1	N	4.0	2.0	2	1	30
20	26	0825	F15	AA21	1	2	0	1.2	.1	N	4.0	2.0	2	1	30
20	26	0845	F15	AA21	1	4	0	1.6	.1	N	4.0	2.0	2	1	30

20	26	0930	F15	AA21	1	4	0	1.6	.1	N	4.0	2.0	2	1	30
20	26	1240	F15	AA22	1	2	0	1.2	.1	N	4.0	2.0	2	1	30
20	26	1325	F15	AA22	1	2	0	1.2	.1	N	4.0	2.0	2	1	30
20	26	1510	F15	AA22	1	2	0	1.2	.1	N	4.0	2.0	2	1	30
20	27	0600	F15	WASHF	1	1	0	2.5	.1	N	4.0	2.0	1		
20	28	0600	F15	PHASF	1	1	0	2.5	.1	N	4.0	2.0	1		
20	30	0600	F15	PFLTF	1	1	0	16.0	.1	N	4.0	2.0	1		
20	33	0600	F15	PHASF	1	1	0	2.5	.1	N	4.0	2.0	1	1	36
20	33	0740	F15	AA21	1	3	3	1.2	.1	N	4.0	2.0	2	1	37
20	33	0825	F15	AA21	1	2	0	1.2	.1	N	4.0	2.0	2	1	37
20	33	0845	F15	AA21	1	4	0	1.6	.1	N	4.0	2.0	2	1	37
20	33	0930	F15	AA21	1	4	0	1.6	.1	N	4.0	2.0	2	1	37
20	33	1240	F15	AA22	1	2	0	1.2	.1	N	4.0	2.0	2	1	37
20	33	1325	F15	AA22,	1	4	0	1.2	.1	N	4.0	2.0	2	1	37
20	33	1510	F15	AA22	1	2	0	1.2	.1	N	4.0	2.0	2	1	37
20	34	0740	F15	AA21	1	1	0	1.2	.1	N	4.0	2.0	2		
20	36	0600	F15	WASHF	1	1	0	2.5	.1	N	4.0	2.0	1		
20	37	0600	F15	PFLTF	1	1	0	16.0	.1	N	4.0	2.0	1		

DAY 26

TIME	MISSION	A/C TYPE	SCHED	(MIN)	(SPARE)	PRIORITY	TAKEOFF	LATENESS	SORTIE LENGTH	LEAD TIME
200	PFLTF	F15	42	42	0	1	600	2+ 0	15+58	4+ 0
200	PFLTF	F15	2	2	0	1	600	2+ 0	15+55	4+ 0
200	PFLTF	F15	8	8	0	1	600	2+ 0	15+49	4+ 0
200	PHASF	F15	1	1	0	1	600	2+ 0	2+22	4+ 0
340	AA21	F15	4	1	3	2	740	2+ 0	1+22	4+ 0
425	AA21	F15	2	1	0	2	825	2+ 0	1+14	4+ 0
445	AA21	F15	4	1	0	2	845	2+ 0	1+32	4+ 0
530	AA21	F15	4	1	0	2	930	2+ 0	1+36	4+ 0
840	AA22	F15	2	1	0	2	1240	2+ 0	1+20	4+ 0
925	AA22	F15	2	1	0	2	1325	2+ 0	1+12	4+ 0
1110	AA22	F15	2	1	0	2	1510	2+ 0	1+15	4+ 0

DAY 27

TIME	MISSION	A/C TYPE	SCHED	(MIN)	(SPARE)	PRIORITY	TAKEOFF	LATENESS	SORTIE LENGTH	LEAD TIME
200	PFLTF	F15	42	42	0	1	600	2+ 0	16+ 7	4+ 0
200	PFLTF	F15	2	2	0	1	600	2+ 0	16+ 4	4+ 0
200	PFLTF	F15	8	8	0	1	600	2+ 0	15+57	4+ 0
200	WASHF	F15	1	1	0	1	600	2+ 0	2+31	4+ 0
340	AA21	F15	4	1	3	2	740	2+ 0	1+18	4+ 0
425	AA21	F15	2	1	0	2	825	2+ 0	1+18	4+ 0
445	AA21	F15	4	1	0	2	845	2+ 0	1+39	4+ 0
530	AA21	F15	4	1	0	2	930	2+ 0	1+40	4+ 0
840	AA22	F15	2	1	0	2	1240	2+ 0	1+18	4+ 0
925	AA22	F15	2	1	0	2	1325	2+ 0	1+14	4+ 0
1110	AA22	F15	2	1	0	2	1510	2+ 0	1+ 8	4+ 0

DAY 28

TIME	MISSION	A/C TYPE	SCHED	(MIN)	(SPARE)	PRIORITY	TAKEOFF	LATENESS	SORTIE LENGTH	LEAD TIME
200	PFLTF	F15	42	42	0	1	600	2+ 0	16+ 8	4+ 0
200	PFLTF	F15	2	2	0	1	600	2+ 0	16+ 6	4+ 0
200	PFLTF	F15	8	8	0	1	600	2+ 0	15+51	4+ 0
200	PHASF	F15	1	1	0	1	600	2+ 0	2+28	4+ 0
200	PHASF	F15	1	1	0	1	600	2+ 0	2+21	4+ 0
340	AA21	F15	4	1	3	2	740	2+ 0	1+13	4+ 0

DAY 29

TIME	MISSION	A/C TYPE	SCHED	(MIN)	(SPARE)	PRIORITY	TAKEOFF	LATENESS	SORTIE LENGTH	LEAD TIME
200	PFLTF	F15	42	42	0	1	600	2+ 0	16+ 8	4+ 0
200	PFLTF	F15	2	2	0	1	600	2+ 0	16+11	4+ 0
200	PFLTF	F15	8	8	0	1	600	2+ 0	16+ 0	4+ 0
340	AA21	F15	4	1	3	2	740	2+ 0	1+18	4+ 0
425	AA21	F15	2	1	0	2	825	2+ 0	1+12	4+ 0
445	AA21	F15	4	1	0	2	845	2+ 0	1+35	4+ 0
530	AA21	F15	4	1	0	2	930	2+ 0	1+39	4+ 0
840	AA22	F15	2	1	0	2	1240	2+ 0	1+16	4+ 0
925	AA22	F15	2	1	0	2	1325	2+ 0	1+ 7	4+ 0
1110	AA22	F15	2	1	0	2	1510	2+ 0	1+ 9	4+ 0

DAY 30

TIME	MISSION	A/C TYPE	SCHED	(MIN)	(SPARE)	PRIORITY	TAKEOFF	LATENESS	SORTIE LENGTH	LEAD TIME
200	PFLTF	F15	42	42	0	1	600	2+ 0	15+55	4+ 0
200	PFLTF	F15	2	2	0	1	600	2+ 0	15+40	4+ 0
200	PFLTF	F15	8	8	0	1	600	2+ 0	15+46	4+ 0
200	PFLTF	F15	1	1	0	1	600	2+ 0	15+52	4+ 0
340	AA21	F15	4	1	3	2	740	2+ 0	1+ 9	4+ 0
425	AA21	F15	2	1	0	2	825	2+ 0	1+ 5	4+ 0
445	AA21	F15	4	1	0	2	845	2+ 0	1+35	4+ 0
530	AA21	F15	4	1	0	2	930	2+ 0	1+23	4+ 0
840	AA22	F15	2	1	0	2	1240	2+ 0	1+18	4+ 0
925	AA22	F15	2	1	0	2	1325	2+ 0	1+15	4+ 0
1110	AA22	F15	2	1	0	2	1510	2+ 0	1+ 9	4+ 0

DAY 31

TIME	MISSION	A/C TYPE	SCHED	(MIN)	(SPARE)	PRIORITY	TAKEOFF	LATENESS	SORTIE LENGTH	LEAD TIME
200	PFLTF	F15	42	42	0	1	600	2+ 0	15+58	4+ 0
200	PFLTF	F15	2	2	0	1	600	2+ 0	16+ 4	4+ 0
200	PFLTF	F15	8	8	0	1	600	2+ 0	15+54	4+ 0

APPENDIX D

JOB CONTROL FILES

1. This appendix lists the job control files and the run specification file used to produce the LCOM simulations. Each file is listed along with a description of how it was used and the purpose it served. For specific guidance on running an LCOM simulation contact William F. Drake at AFMSMET/MEMT, Wright-Patterson Air Force Base, Ohio.

2. Intialization Tape.

This job stream was used to produce the initalization tape from the maintenance data network.

```
0010##NORM
0020$:IDENT:WP1191,AFIT-LSG-77B/DAVIS-SMITH
0030$:USERID:77B52$ZL88
0040$:PROGRAM:RLHS
0050$:PRMFL:H*,E,R,LCOM.II/INPTHSTR
0060$:LIMITS:10,72K,,12K
0065$:FFILE:07,NOSLEW
0070$:TAPE:07X7D,,73627,,F15NET2/RING
0080$:FFILE:09,NOSLEW
0090$:FILE:09,X9S,2L
0110$:PRMFL:17,R,S,CACI/SIMERR
0120SPEC INFO=2 FORM=10
0125$:PRMFL:10,R,L,77B52/NETWORK
0130$:ENDJOB
```

a. The maintenance network was stored in Binary Coded Decimal (BCD) fcrmat without line numbers on the permanent disk file NETWORK.

b. The intialization tape was placed on a tape file F15NET2, which was subsequently input to the main simulation run.

3. Exogenous Events Tape.

This job stream was used to produce the exogenous events tape from the monthly flying schedule.

```
0010##N,R(SL)
0020$:IDENT:WP1191,AFIT-LSG-77B/DAVIS-SMITH
0030$:USERID:77B52$ZL88
0040$:PROGRAM:RLHS
0050$:PRMFL:H*,E,R,LCOM.II/INPTHSTR
0060$:LIMITS:10,30K,,2K
0065$:FFILE:09,NOSLEW
0070$:TAPE:09,X9D,,74907,,JULEXO/RING
0080$:FFILE:07,NOSLEW
0090$:FILE:07,X7S
0110$:PRMFL:17,R,S,CACI/SIMERR
0120SPEC INFO=2 FORM=10
0125$:PRMFL:10,R,L,77B52/JULEXO
0130$:ENDJOB
```

a. The monthly flying schedule was stored on a permanent disk file (JULEXO in this sample) in BCD format without line numbers.

b. The Exogenous Events File was placed on a tape file (JULEXO in this example, line 0070) for subsequent input to the main simulation.

4. Main Simulation

This job stream was used to run the main LCOM simulation.

```
0010##NORM
0020$:IDENT:WP1191,SFIT/LSG,DAVIS-SMITH,77B
0030$:USERID:77B52$ZL88
0040$:LOWLOAD
0050$:OPTION:FORTRAN,GO
0060$:LIBRARY:SL
0070$:SELECT:LCOM.II/MAINCSTR
0080$:EXECUTE:DUMP
0090$:LIMITS:50,100K,-1K,15K
0100$:FFILE:04,NOSLEW
```

```
0110$:FILE:04,X4R,25L
0120$:FILE:08,X8R
0130$:FFILE:07,NOSLEW
0140$:TAPE:07,X7D,,73627,,F15NET2
0150$:TAPE:09,X9D,,71040,,INITDATA/RING
0160$:PRMFL:11,R,S,77B52/CHNG.UNC
0170$:PRMFL:SL,R,S,CACI/SIM2LIB
0180$:FFILE:03,NOSLEW
0190$:TAPE:03,X3D,,72538,,JULEXO
0200$:PRMFL:17,R,S,CACI/SIMERR
0210$:DATA:I*
0220SPEC CHNG=11 DATA=09 EXOG=03
0230$:SYSTOUT:$$
0240$:SYSOUT:P*
0250$:ENDJOB
```

a. The initialization tape (line 0140) and the exogenous events tape (line 0190) were produced prior to this run.

b. The run specification file (CHNG.UNC) had to be extablished on a permanent disk file in BCD format prior to running this job.

5. Run Specification File

This file was established on disk and was used to control production of the Performance Summary Report, input the random seed specify the burn-in period, and specify the number of days to be simulated.

```
*COPY CHNG.UNC
ISEED       1    85.0
ISEED       2    85.0
ISEED       3    85.0
WARMUP      7
RFREQ             7.0
RCYC        5
IPSTAT             .5
BOSTAT             .5
QSTAT              .5
ITEM               .5
MNSTAT             .5
STOP             45.05
```

a. The cards labeled ISEED were used to input the random seeds. One seed was required for the task selection, one seed was required for failure model operation, and a third seed was required for task duration calculations.

b. The card labeled WARMUP specified the burn-in period of seven days.

c. The card RFREQ specified the frequency of the level 1 PSRs, one each seven days.

d. The card labeled RCYC specified the frequency of the level 2 PSRs, one report five weeks after burn-in.

e. The card labeled STOP was used to specify the number of days to be simulated.

f. The remaining cards were used for debugging purposes and were not required for a simulation run.

APPENDIX E

SAMPLE PERFORMANCE SUMMARY REPORT

This appendix presents a sample of a typical Performance Summary Report. The simulated performance variables of interest in this study are contained on the first page of the PSR on lines six, seven and eight.

MOM NUMBER ALPHA   P E R F O R M A N C E   S U M M A R Y   PERIOD FROM 7.0 TO 42.0   LEVEL 2

O P E R A T I O N S	TOTAL	CONVF	ABF	PHASE	WASHE	PFLTF	OTHER
1 NUMBER OF MISSIONS REQUESTED	281.00	0.	152.00	9.00	7.00	113.00	0.
2 NUMBER ACCOMPLISHED	281.00	0.	152.00	9.00	7.00	113.00	0.
3 PERCENT ACCOMPLISHED	100.00	0.	100.00	100.00	100.00	100.00	0.
8 NUMBER OF SORTIES REQUESTED	2250.00	0.	434.00	10.00	10.00	1796.00	0.
7 NUMBER ACCOMPLISHED	2189.00	0.	373.00	10.00	10.00	1796.00	0.
0 PERCENT ACCOMPLISHED	97.29	0.	85.94	100.00	100.00	100.00	0.
11 NUMBER OF WEATHER CANCELS	0.	0.	0.	0.	0.	0.	0.
12 NUMBER OF WEATHER DELAYS	0.	0.	0.	0.	0.	0.	0.
13 NUMBER OF ALERT REPLENISHMENT	0.	0.	0.	0.	0.	0.	0.
14 NUMBER OF ATTRITIONS	0.	0.	0.	0.	0.	0.	0.
15 NUMBER OF BAM REPAIRS	0.	0.	0.	0.	0.	0.	0.
16 NUMBER OF AIR ABORTS(TOTAL)	0.	0.	0.	0.	0.	0.	0.

A I R C R A F T	TOTAL	FTS	OTHER
13 NUMBER OF AIRCRAFT AUTH.(EOP)	72.00	72.00	0.
14 NUMBER OF AIRCRAFT-DAYS AVAIL	2520.00	2520.00	0.
15 PCT SORTIES(INCL ALERT)	48.44	48.44	0.
16 PCT UNSCHED MAINTENANCE	3.44	3.44	0.
17 PCT SCHED MAINTENANCE	58.90	58.90	0.
18 PCT NORS	0.	0.	0.
19 PCT MISSION WAIT STATUS	13.10	13.10	0.
20 PCT SERVICE + WAITING	0.	0.	0.
21 PCT OPERATIONALLY READY	31.14	31.14	0.
22 AVG. AC POST SORTIE TIME(HRS)	1.43	1.43	0.
23 AVG. NO. OF SORTIES/ A/C /DAY	.87	.87	0.
24 FLYING HOURS	29297.30	29297.30	0.
17 NUMBER OF FCF TASKS FLOWN	0.	0.	0.
18 AVG. AC PRE SORTIE TIME(HRS)	.60	.60	0.

P E R S O N N E L	TOTAL	326A1	326B2	326R1	326R2	326C2	326I2	421A3	421X2	422B1	422X2
27 MANHOURS AVAILABLE (100)	1477.60	120.40	131.60	36.40	103.60	142.00	84.00	84.00	142.80	89.60	33.60
28 PERCENT UTILIZATION	3.73	5.59	4.97	9.93	2.21	2.47	.06	3.33	3.82	3.40	.59
29 MANHOURS USED (100)	129.82	6.73	6.53	3.62	2.29	3.53	.05	2.80	5.45	3.04	.20
30 PCT UNSCHED MAINTENANCE	62.22	100.00	99.56	100.00	94.23	100.00	100.00	100.00	88.73	93.80	48.91
31 PCT SCHED MAINTENANCE	37.78	0.	.44	0.	5.77	0.	0.	0.	11.27	6.12	51.09
33 NUMBER OF MEN DEMANDED	1852.00	138.00	312.00	105.00	145.00	212.00	19.00	906.00	253.00	177.00	19.00
34 PCT AVAILABLE (PRIME)	98.06	00.00	00.001	90. 9	00.00	00.00	00.00	00.00	00.00	00.00	00.00
35 PCT AVAILABLE (SUBST.)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36 PCT PROV. BY EXPEDITE	.08	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37 PCT PROV. BY PREEMPTION	.04	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38 PCT DEMANDS NOT SATIS.	1.02	0.	0.	3.01	0.	0.	0.	0.	0.	0.	0.
39 OVERTIME MANHOURS USED (100)	.03	.00	0.	.00	0.	0.	0.	0.	0.	0.	0.
40 SIMULATED MH PER FLYING HOUR	.44	.02	.07	.01	.01	.01	.00	.01	.07	.01	.00

RUN NUMBER ALPHA   P E R F O R M A N C E   S U M M A R Y   PERIOD FROM 7.0 TO 42.0   LEVEL 2

P E R S O N N E L	TOTAL	423X0	42400	431C1	431P1	431X1	431Y1	432T0	43200	462X0	462Y0
27 MANHOURS AVAILABLE (100)	3477.60	92.40	44.00	100.00	196.00	652.40	11.20	20.00	404.40	90.00	90.00
28 PERCENT UTILIZATION	3.73	2.09	10.20	.27	2.20	5.63	9.48	20.52	4.50	3.52	.04
29 MANHOURS USED (100)	129.82	2.40	4.60	.27	4.31	36.74	1.90	5.74	21.00	3.45	.63
30 PCT UNSCHED MAINTENANCE	62.22	90.62	100.00	72.66	0.	24.39	100.00	100.00	90.63	0.	79.39
31 PCT SCHED MAINTENANCE	37.78	3.38	0.	27.34	100.00	75.61	0.	0.	9.37	100.00	20.61
33 NUMBER OF MEN DEMANDED	15852.00	134.00	75.00	20.00	562.00	8457.00	81.00	412.00	1412.00	519.00	36.00
34 PCT AVAILABLE (PRIME)	90.06	100.00	97.33	100.00	93.42	99.94	82.54	86.41	100.00	97.80	100.00
35 PCT AVAILABLE (SUBST.)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36 PCT PROV. BY EXPEDITE	.08	0.	1.33	0.	0.	0.	0.	0.	0.	0.	0.
37 PCT PROV. BY PREEMPTION	.14	0.	1.33	0.	0.	0.	1.59	0.	0.	.39	0.
38 PCT DEMANDS NOT SATIS.	1.32	0.	0.	0.	6.58	.00	15.87	13.59	0.	1.73	0.
39 OVERTIME MANHOURS USED (100)	.13	0.	0.	0.	0.	0.	.00	.02	0.	0.	0.
40 SIMULATED MH PER FLYING HOUR	.14	.01	.02	.00	.01	.13	.00	.02	.07	.01	.00

P E R S O N N E L	TOTAL	402Z0	531X0	531X1	531X3	531X4	531X5	536X0	OTHER
27 MANHOURS AVAILABLE (100)	3477.60	464.00	20.00	22.40	75.60	36.40	47.60	20.00	0.
28 PERCENT UTILIZATION	3.13	2.08	3.23	1.60	4.10	.59	.42	.01	0.
29 MANHOURS USED (100)	129.12	9.08	.91	.36	3.10	.22	.20	.00	0.
30 PCT UNSCHED MAINTENANCE	62.22	2.75	98.91	100.00	91.17	0.	0.	100.00	0.
31 PCT SCHED MAINTENANCE	37.18	97.25	1.09	0.	8.83	100.00	100.00	0.	0.
33 NUMBER OF MEN DEMANDED	15952.00	3500.00	83.00	12.00	174.00	10.00	4.00	2.00	0.
34 PCT AVAILABLE (PRIME)	98.06	94.92	100.00	100.00	100.00	100.00	100.00	100.00	0.
35 PCT AVAILABLE (SUBST.)	0.	0.	0.	0.	0.	0.	0.	0.	0.
36 PCT PROV. BY EXPEDITE	.08	.31	0.	0.	0.	0.	0.	0.	0.
37 PCT PROV. BY PREEMPTION	.04	.00	0.	0.	0.	0.	0.	0.	0.
38 PCT DEMANDS NOT SATIS.	1.82	4.00	0.	0.	0.	0.	0.	0.	0.
39 OVERTIME MANHOURS USED (100)	.01	0.	0.	0.	0.	0.	0.	0.	0.
40 SIMULATED MH PER FLYING HOUR	.41	.03	.00	.00	.01	.00	.00	.00	0.

S H O P R E P A I R	TOTAL	PAR11	PAR12	PAR13	PAR14	PAR15	PAR16	PAR17	PAR18	PAR19	PAR1A
44 NO. OF REPARABLE GENERATIONS	541.00	99.00	25.00	15.00	13.00	52.00	9.00	14.00	3.00	16.00	26.00
45 PCT BASE REPAIR	49.54	41.41	44.00	13.33	76.92	57.69	66.67	28.57	33.33	12.50	69.23
46 PCT DEPOT REPAIR	50.46	58.59	56.00	86.67	23.08	42.31	33.33	71.43	66.67	87.50	30.77
47 AVERAGE BASE REPAIR CYCLE	.22	.30	.19	.11	.00	.32	.10	.11	.10	.11	.31
48 PCT ACTIVE REPAIR 1	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
49 PCT WHITE SPACE	.00	.00	.00	.00	.00	.00	.00	.00	0.	0.	.00
50 NO. OF ITEMS IN REPAIR (END)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
51 NO. OF ITEMS BACKORDERED (END)	115.00	20.00	7.00	8.00	2.00	7.00	0.	5.00	1.00	7.00	3.00

S H O P R E P A I R	TOTAL	PAR1B	PAR1C	PAR1D	PAR1E	PAR1F	PAR1G	PAR1H	PAR1I	PAR1J	OTHER
44 NO. OF REPARABLE GENERATIONS	541.00	12.00	26.00	33.00	24.00	12.00	23.00	78.00	20.00	41.00	0.
45 PCT BASE REPAIR	49.54	41.67	76.92	78.79	91.67	58.33	52.17	32.05	55.00	36.59	0.
46 PCT DEPOT REPAIR	50.46	58.33	23.08	21.21	8.33	41.67	47.83	67.95	45.00	63.41	0.
47 AVERAGE BASE REPAIR CYCLE	.22	.30	.24	.14	.15	.04	.20	.25	.20	.10	0.
48 PCT ACTIVE REPAIR	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.
49 PCT WHITE SPACE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	0.
50 NO. OF ITEMS IN REPAIR (END)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
51 NO. OF ITEMS BACKORDERED (END)	115.00	3.00	3.00	3.00	0.	2.00	4.00	20.00	3.00	9.00	0.

AD-A047 227 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OHIO SCHO--ETC F/G 1/5
AN EVALUATION OF THE CAPABILITY OF THE LOGISTICS COMPOSITE MODE--ETC(U)
SEP 77 C G DAVIS, C T SMITH

UNCLASSIFIED AFIT-LSSR-2-77B NL

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NUM NUMBER ALPHA   P E R F O R M A N C E   S U M M A R Y   PERIOD FROM 7.0 TO 47.0   LEVEL 2

S U P P L Y	TOTAL	PART1	PART2	PART3	PART4	PART5	PART6	PART7	PART8	PART9	PARTA
54 TOT DOLLAR (INVEST.)(000)(EOP)	57390.00	4650.00	7400.00	7400.00	7400.00	7400.00	7400.00	7400.00	7400.00	7400.00	7400.00
55 FILL RATE PERCENT	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
56 NUMBER OF BACKORDER-DAYS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57 NUMBER OF UNITS DEMANDED	930.00	90.00	25.00	15.00	13.00	51.00	9.00	14.00	3.00	16.00	74.00
58 PCT OFF-THE-SHELF	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
59 PCT EXPEDITED REPAIR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60 PCT PREEMPTION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61 PCT DEMANDS NOT SATIS.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62 NUMBER OF CANNIBALIZATIONS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63 NO. ITEMS ON BACKORDER (EOP)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

S U P P L Y	TOTAL	PARTB	PARTC	PARTD	PARTE	PARTF	PARTG	PARTH	PARTI	PARTJ	OTHER
54 TOT DOLLAR (INVEST.)(000)(EOP)	57390.00	1050.00	2400.00	7400.00	2750.00	3600.00	3600.00	3600.00	3600.00	3600.00	0.
55 FILL RATE PERCENT	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.
56 NUMBER OF BACKORDER-DAYS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57 NUMBER OF UNITS DEMANDED	510.00	11.00	25.00	33.00	70.00	12.00	23.00	77.00	20.00	30.00	0.
58 PCT OFF-THE-SHELF	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.
59 PCT EXPEDITED REPAIR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60 PCT PREEMPTION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61 PCT DEMANDS NOT SATIS.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62 NUMBER OF CANNIBALIZATIONS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63 NO. ITEMS ON BACKORDER (EOP)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

E Q U I P M E N T	TOTAL	AHM72	MSCHP	C5	B40	FH 00	LCADT	MJI	PTS1	PTS10	PTS11
68 TOT DOLLAR (INVEST.)(000)(EOP)	56000100	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00	000.00
69 EQUIPMENT HOURS AUTH. (100)	47040.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00
70 EQUIPMENT HOURS AVAIL. (100)	47040.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00
71 PCT USED-UNSCHED MAINT	.07	0.	.05	.49	1.33	0.	0.	0.	0.	.00	.01
72 PCT USED-SCHED MAINT	.01	.01	0.	.03	.27	0.	.04	0.	0.	0.	0.
73 PCT UNUSED	99.02	99.99	99.95	99.70	98.41	100.00	99.96	100.00	100.00	100.00	99.99
74 NUMBER OF BACKORDER-DAYS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75 NUMBER OF UNITS DEMANDED	2771.00	2.00	12.00	309.00	1635.00	0.	117.00	0.	0.	1.00	6.00
76 PCT AVAILABLE	100.00	100.00	100.00	100.00	100.00	0.	100.00	0.	0.	100.00	100.00
77 PCT PROV. BY EXPEDITE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
78 PCT PROV. BY PREEMPTION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
79 PCT DEMANDS NOT SATIS.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
80 EQUIP HOURS BACKLOG(100)(EOP)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

RUN NUMBER ALPHA   P E R F O R M A N C E   S U M M A R Y   PERIOD FROM 7.0 TO 42.0   LEVEL 2

E Q U I P M E N T	TOTAL	PTS7	PTS8	PTS9	TSC	TSD	TSA	TN270	TMD	MOUCO	PTS13
68 TOT DOLLAR INVEST.(1000)(EQP)	50000.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00	800.00
69 EQUIPMENT HOURS ONTO. (100)	47040.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00
70 EQUIPMENT HOURS AVAIL. (100)	47040.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00	840.00
71 PCT NSFO-UNSCHED MAINT	.07	.00	0.	.10	.20	.20	.27	.39	0.	0.	0.
72 PCT NSFO-SCHED MAINT	.01	0.	0.	0.	0.	0.	0.	.01	.01	.03	0.
73 PCT NONSFO	99.92	100.00	100.00	99.82	99.77	99.71	99.73	99.40	99.99	99.87	100.00
74 NUMBER OF BACKORDER-DAYS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75 NUMBER OF UNITS DEMANDED	2721.00	2.00	0.	20.00	87.00	94.00	60.00	207.00	10.00	10.00	0.
76 PCT AVAILABLE	100.00	100.00	0.	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.
77 PCT PROV. BY EXPEDITE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
78 PCT PROV. BY PREEMPTION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
79 PCT DEMANDS NOT SATIS.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
80 EQUIP HOURS BACKLOG(100)(EQP)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

E Q U I P M E N T	TOTAL	PTS22	PTS23	PTS34	PTS35	PTS39	PTS5	OTHER
68 TOT DOLLAR INVEST.(1000)(EQP)	56000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	0.
69 EQUIPMENT HOURS ONTO. (100)	47040.00	840.00	840.00	840.00	840.00	840.00	840.00	0.
70 EQUIPMENT HOURS AVAIL. (100)	47040.00	840.00	840.00	840.00	840.00	840.00	840.00	0.
71 PCT NSFO-UNSCHED MAINT	.07	0.	0.	0.	0.	0.	0.	0.
72 PCT NSFO-SCHED MAINT	.01	0.	0.	0.	0.	0.	0.	0.
73 PCT NONSFO	99.92	100.00	100.00	100.00	100.00	100.00	100.00	0.
74 NUMBER OF BACKORDER-DAYS	0.	0.	0.	0.	0.	0.	0.	0.
75 NUMBER OF UNITS DEMANDED	2721.00	0.	0.	0.	0.	0.	0.	0.
76 PCT AVAILABLE	100.00	0.	0.	0.	0.	0.	0.	0.
77 PCT PROV. BY EXPEDITE	0.	0.	0.	0.	0.	0.	0.	0.
78 PCT PROV. BY PREEMPTION	0.	0.	0.	0.	0.	0.	0.	0.
79 PCT DEMANDS NOT SATIS.	0.	0.	0.	0.	0.	0.	0.	0.
80 EQUIP HOURS BACKLOG(100)(EQP)	0.	0.	0.	0.	0.	0.	0.	0.

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SELECTED BIBLIOGRAPHY

A. REFERENCES CITED

1. Abbott, Major James E., USAF and Captain George W. Jones, USAF. AFIT/CREATE System and Applications Software. Wright-Patterson AFB OH: AFIT/LS, September 1975.

2. Adams, Senior Master Sergeant Paul S., USAF. 1st Tactical Fighter Wing/MAMP, Langley AFB VA. Personal interviews conducted intermittently from May 1977 through August 1977.

3. Berman, Morton B. "Improving SAC Aircrews and Aircraft Scheduling to Increase Resource Effectiveness." R-1435-PR, RAND Corporation, Santa Monica CA, July 1974.

4. ________. "Scheduling Aircrews and Aircraft: Problems of Resource Allocations in the Strategic Air Command." R-1610-PR, RAND Corporation, Santa Monica CA, January 1975.

5. Boyd, Major James A., USAF, and Major Gary J. Toy, USAF. "An Evaluation of the Use of the Logistics Composite Model to Measure the Effectiveness of Aircraft Flying Schedules." Unpublished master's thesis, AFIT/SL, Wright-Patterson AFB OH, 1975. ADA 016267.

6. Clark, Charles T. and Lawrence L. Schkade. Statistical Analysis for Administrative Decisions. Cincinnati: South Western Publishing Co., 1974.

7. DeGovanni, Captain George, USAF, and Major Donald M. Douglas, USAF. "Estimation of F-15 Peacetime Maintenance Manpower Requirements Using the Logistics Composite Model." Unpublished master's thesis GOR-SM-76D-5, AFIT/ENS, Wright-Patterson AFB OH, 1976.

8. Drake, William F., III. Logistics Composite Model Users Reference Guide Update. AFLC/ADDR Report 74-1. Wright-Patterson AFB OH: HQ/AFLC, November 1974.

9. ________ and others. Logistics Composite Model Users Reference Guide. AFLC Report 70-1. Wright-Patterson AFB OH: HQ/AFLC, January 1970.

10. ________, Air Force Maintenance and Supply Management Engineering Team. Wright-Patterson AFB OH. Personal interviews conducted intermittently from November 1976 through August 1977.

11. Duncan, Captain William D., Jr. and Captain Curtis H. Gwaltney. "An Evaluation of the Effects of Selected Scheduling Rules on Aircraft Sortie Effectiveness." Unpublished master's thesis, AFIT/LS, Wright-Patterson AFB OH, 1977.

12. Fisher, Captain R. R., USAF, and others. "The Logistics Composite Model: An Overall View." Memorandum No. Rm-5544-PR, RAND Corporation, Santa Monica CA, May 1968.

13. Glad, Major Richard F., USAF and Major Robert T. Pierce, USAF. "A Comparison of Selected Scheduling Heuristics for a TAC F-4E Maintenance Organization." Unpublished master's thesis, AFIT/SL, Wright-Patterson AFB OH, 1976. ADA 032327.

14. Gribling, Colonel R. L., USAF. Director, Manpower and Organization, DCS/PLANS, HQ TAC. Letter, subject: Logistics Research on Maintenance Sortie Production Capability Models, to AFLMC/OA, 25 April 1977.

15. Kiviat, Phillip J. "Computer Assisted Maintenance Planning." Memorandum No. RM-4563-PR, RAND Corporation, Santa Monica CA, July 1965.

16. ________. "Manpower Requirements Prediction and Allocation for Unscheduled Maintenance on Aircraft." Memorandum No. RM-5215-PR, RAND Corporation, Santa Monica CA, February 1967.

17. Lowell, First Lieutenant James R., USAF. 4400 MES/OLAA. Wright-Patterson AFB OH. Personal interview. Conducted during February 1977.

18. Naylor, Thomas H., Joseph L. Balinfy, Donald S. Barclide, and Kong Chu. Computer Simulation Techniques. New York: John Wiley and Sons, Inc., 1966.

19. Talbott, Captain Carlos M., USAF. Logistics Management Center. Gunter AFS AL. Personal interview. Conducted during January 1977.

20. Tetmeyer, Donald C., Lieutenant Colonel, USAF. ASD/ENECC. Wright-Patterson AFB OH. Personal interview. Conducted during February 1977.

21. Tetmeyer, Donald C. and William D. Moody. Simulating Maintenance Manning for New Weapon Systems: Building and Operating a Simulation Model. AFHRL-TR-74-97 (II). Brooks AFB TX: HQ Air Force Human Resources Laboratory, December 1974.

22. U.S. Air Force Management Engineering Agency. LCOM II, Standard System, User Documentation (Preliminary). Wright-Patterson AFB OH: AFMSMET/MEMT, 15 June 1977.

23. U.S. Air Force Tactical Air Command. Logistics Compostie Model: Computer Simulation Technique for Determining Aircraft Maintenance Manpower Requirements. Langley AFB VA, January 15, 1977.

24. U.S. Air Force Tactical Air Command. Monthly Maintenance Data Analysis Report. RCS: TAC LGY (M) 7302 Part I. 1st TAC Fighter Wing, Langley AFB VA, December 1976.

25. U.S. Department of the Air Force. Maintenance Management. Vol. I. AFM 66-1. Washington: Government Printing Office, 1 November 1975.

26. ________. Maintenance Management. Vol. II. AFM 66-1. Washington: Government Printing Office, 1 November 1975.

27. Yates, Captain Gerald A., USAF, and First Lieutenant Richard Fritz, USAF. "A Computer Simulation of Maintenance Manpower Requirements for the DC-130H." Unpublished master's thesis GOR-SM-75D-5, AFIT/ENS, Wright-Patterson AFB OH, 1975. ADA 020229.

B. RELATED SOURCES

Hillier, Fredrick S. and Gerald J. Lieberman. Operations Research. San Francisco: Holden-Day, Inc., 1974.

U.S. Department of the Air Force. A Study of the Automation of the Logistics System at Base Level. Vol. I: Washington: HQ USAF, 1973.

U.S. Tactical Air Command. Logistics Composite Model (LCOM) Study. Vol. I and Vol. II. Langley AFB VA: HQ TAC, 1973.

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